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User's Guide to RMM Software:

A Short-Run Partial Equilibrium Model for Economic Valuation of Wildland Resource Benefits

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ABSTRACT

The Recreation Market Model (RMM) is a short-run partial equilibrium market simulation model for use in planning and policy analysis. The market structure of RMM is the on-site supply of recreation opportunities at a recreation area and the on-site aggregate demand for recreation opportunities from many origins within the site's market area. The model allows analysts and policymakers to observe the effects management policies would have on the economic welfare of users and suppliers before they are implemented. RMM performs three primary analyses: (1) demand analysis (which includes an updated and enhanced version of the Rocky Mountain Travel Cost Model (RMTCM)), (2) supply analysis, and (3) short-run partial equilibrium analysis. The equilibrium analysis isolates the point of intersection between the demand and supply curves. The program is menu-driven from a main menu that includes data input and modification, variable definition, functional form identification, regression analysis, and graphing. Output from the program includes graphs of demand and supply curves and estimates of consumer and producer surplus. The program is written in FORTRAN 77 for use on an IBM-compatible personal computer.

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NOTE

There is no cost for this computer program. However, the requestor must provide a formatted double-sided double-density or high-density "floppy" (5 1/4" or 3 1/2") diskette, suitable for use in IBM personal computers (PC's) or compatibles, and enclose a self-addressed, postage-paid mailer with suitable protection for the diskette. Execution of RMM requires an IBM-compatible PC with 506K of available memory. For further information write Valuation of Wildland Resource Benefits Research Work Unit, Rocky Mountain Forest and Range Experiment Station, USDA Forest Service, 240 West Prospect Road, Fort Collins, CO 80526-2098.

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The Recreation Market Model (RMM) is a short-run partial equilibrium market simulation model for use in planning and policy analysis of recreation sites. RMM performs three primary analyses: (1) demand analysis (travel cost analysis), (2) supply analysis, and (3) partial equilibrium analysis between the consumer demand function and the operator's on-site marginal cost (supply) function.

Keywords: Travel cost model, equilibrium model, supply function, economic valuation

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INTRODUCTION

The Recreation Market Model (RMM) is an interactive computer program that simulates a short-run partial equilibrium market for visits to a single recreation site. The program simulates this equilibrium as the intersection of the consumer demand function with the operator's on-site marginal cost (supply) function. The demand function used in the model is the residual marginal willingness to pay for entry, after payment of all other costs including travel cost. This demand function is comparable to the residual bid for stumpage, after payment of harvest costs. Based on the assumption that visitors respond identically to changes in travel cost and access fee, the demand function is the so-called "second stage" function of travel cost analysis (Dwyer et al. 1977).

The supply function is the relationship between the number of visitors arriving at the site and the site operator's short-run marginal cost of admitting that number, given fixed site capacity. The locus of the simulated market is thus the "gate" through which visitors obtain entry to the site. The good is admission through that gate.

To be manageable, the analysis must also assume a specific time period, and the demand and supply functions should be average functions for that time period. The model is thus very simple; it cannot deal with dynamic fluctuations in persons at one time or with general equilibrium effects on prices or conditions at other sites. All prices and conditions outside the site in question are assumed to be constant.

This user's manual provides information needed to operate the RMM software. Efficient use of RMM, however, requires an understanding of multiple regression analysis, basic concepts in microeconomic theory, travel cost analysis, and market assessment. Without this knowledge, parts of this publication may be difficult to understand, and the possibility of misapplication of the program is high. For background reading, users are referred to Dwyer et al. (1977), U.S. Water Resources Council (1979), Walsh (1986), and Rosenthal et al. (1984) on the travel cost model (TCM); and to Freeman (1983) and Nicholson (1985) on markets and market models. The RMM software is based on work originally done by Rosenthal et al. (1986) and Watkins (1987).

RMM is intended for "quick and dirty" estimation of recreation values from secondary data. It is not a state-of-the-art package for estimating demand functions or for sophisticated resource valuation. The TCM component employs the zonal method and is thus vulnerable to aggregation error. The estimation component uses ordinary least squares (OLS) and is subject to the weaknesses of that approach. Several commonly used functional forms are available in RMM for both supply and demand, and the user can create additional forms through data transformation. We urge caution, however, in the selection of functional form. The user needs to be aware that transformation of the dependent variable may cause bias.

The program can estimate the supply and demand functions from data supplied by the user. It can also accept functions estimated externally by other means, as long as these functions fit the available form or can be made to fit through transformation. RMM can compute consumer and producer surplus caused by nonmarginal price changes. It can also describe the second stage demand function and the revenues associated with various fee increases. It further allows computation of the marginal price and quantity at which supply and demand are equal, as well as changes in all these quantities caused by changes in the demand or supply equations. Far beyond its limited estimation capability, RMM is thus useful for educational gaming, as a computational tool for analysis of benefits with known supply and demand equations, and for analysis of sensitivity of benefits and prices to hypothetical changes, such as changes over time. Some users may want to estimate the supply and demand functions by more rigorous statistical analyses and then use this program to analyze benefits, prices, and revenues or to examine the relationship between price and quantity.

The reader should review the entire user's manual, with careful attention to the sections on data collection and preparation, before using RMM.

USING THE RMM PROGRAM

GETTING STARTED[4]

The way you start RMM depends on whether your personal computer has hard disk or floppy disk drives. With a hard disk system, copy the RMM.EXE file from the floppy to the hard disk. Make sure the RMM.EXE file is located in a directory contained in the "path" command in the autoexec.bat file (see your disk operating system manual for details). You can execute RMM from this directory or from the directory in which your input data is located. Start the program by typing RMM and pressing the ENTER[5] key on your keyboard.

With a two-floppy disk system, insert the diskette containing RMM.EXE in drive A and place a blank formatted diskette in drive B; make drive B the default drive. Start the program from drive B by typing A:RMM. On a one-floppy system, insert the diskette and start the program by typing RMM.

When RMM is running, it will read files from and write files to the default drive and default directory. If the user wants to read a data file from other than the default drive and directory, RMM requires a valid drive and path specification. For example to retrieve the file named RMM.DAT from the "INPUT" directory of the A drive, type A: \ INPUT \ RMM.DAT when asked for the name of the input data file. The option to specify the drive and directory containing the data file is only available if the DOS version is 3.0 or newer. Users with older versions of DOS must have their data in the default drive and directory. With a one-floppy system, the data and program must be on the same diskette.

As RMM is executing the regression portion of the program, it temporarily writes the user's data file to a disk drive and then rereads it once the regression is complete. This is done to conserve memory. The temporary file is written to the default drive and default directory. There is no way to alter this. Users should make sure there is enough storage space on the default drive and directory to accommodate this temporary file.

Except for special system files created by RMM, the program can read only ASCII files with numeric data. If such a file is printed it will look "normal" and contain only numbers, decimal points, negative signs, positive signs, and blanks (or commas). RMM will not read .DIF files or .WK1 files.

The simplest way to create an ASCII file is to use a word processing program in nondocument (ASCII) mode or a full-screen editor. Alternatively, ASCII files can be formed using the EDLIN feature of DOS. Some spreadsheet programs, such as Lotus 1–2–3,[6] will write ASCII files if a print file is routed to an output file rather than a printer. On Lotus 1–2–3, be sure to specify "unformatted" output as one of the print options to avoid page breaks in the data set. An advantage of using a spreadsheet program is that very complex data transformations can all be accomplished inside the spreadsheet. The transformed data then can be written as an ASCII file and subsequently used as input for RMM.

MATHEMATICAL ERRORS

Mathematical computations in RMM are subject to limits imposed by the program in conjunction with FORTRAN 77. Economic analyses in the program may require transformations of functional forms using natural logarithmic and exponential operations. These transformations can create very large or very small numbers, from numbers whose magnitude would not normally create problems. Maximum and minimum limits expressed in exponential notation are E+38 and E-38, respectively. Care must be taken both in selecting functional forms and in specifying coefficients so that these limits are not exceeded. Numbers exceeding the maximum often create a FORTRAN "overflow" error and automatically exit the user from RMM. Numbers below the minimum can cause "divide by zero" errors in FORTRAN, also leading to an automatic exit from RMM. Exceeding the mathematical capabilities of the program is the most common FORTRAN error you are likely to encounter while running RMM. One way to reduce the likelihood of approaching the mathematical limits is to scale those variables that typically cause problems; for example, income and population, which have large values, can be expressed in thousands.

PROGRAM STRUCTURE

The RMM program is divided into two main analysis modules, demand and supply, which can be run independently or together on the same run. The equilibrium analysis requires that both modules be executed during

[4]Refer to the README file on the program diskette for updated information about loading RMM onto your system.

[5]The ENTER key must be depressed to execute a command in the DOS environment.

[6]The use of trade and company names is for the benefit of the reader; such use does not constitute an official endorsement or approval of any service or product by the U.S. Department of Agriculture to the exclusion of others that may be suitable.

the same RMM session. Either module can be run first, with that output stored for later use in the equilibrium analysis after the second module is completed. The demand, supply, and equilibrium analyses in RMM are discussed below.

DEMAND ANALYSIS

The demand module incorporates a Travel Cost Model (TCM) methodology for estimation of the dollar value of recreation benefits provided at recreation sites. The program outlines a step-by-step procedure to build a TCM. For a conceptual overview of TCM, refer to Dwyer et al. (1977), Rosenthal et al. (1984), Walsh (1986), or U.S. Water Resources Council (1979).

DATA COLLECTION

For travel cost analysis, data can be classified as either primary or secondary, and also as essential or nonessential. The four types of data used in RMM and the specific variables associated with each type are:

Type 1: Primary, Essential
- where visitors to the site are from (origin)

Type 2: Secondary, Essential
- price of a trip
  - distance
  - cost per mile
  - persons per vehicle
  - average travel speed
  - per-capita income to compute opportunity cost of time
  - entry fee
- trips per capita
  - trips from each origin
  - sampling rate[7]
  - population of origin

Type 3: Primary, Nonessential
- length of stay
- single versus multiple destination trips

Type 4: Secondary, Nonessential
- substitute recreation areas
  - imperfect substitutes
  - perfect substitutes
- demographic characteristics of origins
- site characteristics of recreation area.

Type 1 Data: Primary, Essential

"Primary data" refers to data that must be collected about persons using the recreation site being modeled. "Essential data" refers to data needed to make estimation of a travel cost model mathematically possible. In the RMM demand module, there is only one primary and essential piece of data: the origin or location from which the recreationists who visited the site began their trip. One of the main reasons for the widespread use of the TCM is that it can be run with a minimal amount of information.

Counties or groups of counties are often the origins for a zonal TCM analysis. The best way to identify the origin of trips is to directly ask recreationists their city and county of residence. A second way is to obtain information about the zip code of the home address, often found on visitor registration forms. The latter method is less desirable because zip codes must be converted to cities and counties if counties are selected as the unit of analysis. Also, zip code boundaries do not always correspond with city and county boundaries.

Type 2 Data: Secondary, Essential

In the TCM the per-capita visitation rate of zones or origins is regressed on, as a minimum, the price of a trip to the recreation site. To use RMM, type 1 data must be combined with secondary information to calculate the value of the independent (price) and dependent (visits per capita) variables for each origin or zone of origin.

[7] *Essential to estimate total consumer surplus, but not essential to estimate consumer surplus per trip.*

To calculate trips per capita in zonal TCM, it is necessary to form a number of zones of origin around the recreation site. Zones of origin can be defined as concentric rings around the recreation site (Clawson and Knetsch 1966, Sutherland 1982) or as individual units of population located around the site. The least amount of aggregation is desirable. In practice, zones of origin are most easily defined as counties or aggregations of counties. Using individual counties is preferable to concentric rings because two counties located the same distance from the study site might have different visitation rates. If concentric rings are used, information is lost in the aggregation process as the two counties are averaged into one large origin. The concentric ring method also tends to cause collinearity between population and distance. Forming origins is discussed in more detail later.

Figure 1 shows a hypothetical study site and 12 origins or zones of origin forming the market area around the site. Once the origins are defined, the type 1 information about where visitors come from can be used to determine the number of trips originating from each origin or zone. Trips per capita is calculated by dividing the number of trips from each origin or zone by the population (available from census data) of that origin or zone.

Usually, only a fraction of the trips to a recreation site are sampled. Therefore, the number of trips sampled from each origin or zone must be multiplied by the inverse of the sampling rate to estimate the total number of trips from a zone or origin. If the sampling rate is not known, RMM can still be run using only the sampled trips, as long as the sampling rate is uniform across origins. In this case, the consumer surplus per trip for the site is valid, but the total consumer surplus for the site cannot be determined. Consumer surplus is defined as the amount recreationists are willing to pay, in excess of existing costs, for the right to visit the study recreation site.

In TCM the distance between an origin and the recreation site is used as a surrogate for the price in the demand relationship. Distances are converted to prices by calculating the variable costs of travel between an origin and the destination and the opportunity cost of the time spent traveling. The price also includes the gate fee for entry to the site. The full specification of the per-person price of a round-trip from an origin i (i = 1,n) to the recreation site is defined as:

$$P_i = \frac{(d_i)\cdot(a)\cdot(b)}{e} + \frac{(d_i)\cdot(a)\cdot(t)}{c} + \frac{f}{e} \qquad [1]$$

where P_i = dollar cost per person of a round-trip from the origin to the recreation site
d_i = distance from the ith origin to the recreation site
a = 1 if d is the round-trip distance, or 2 if d is the one-way distance
b = variable operating cost, in dollars per mile, for a vehicle (usually in the range of \$0.10 to \$0.25)
e = average number of persons per vehicle
t = hourly opportunity cost of travel time (recommend using 25–50% of the average hourly wage rate)
c = average travel speed in miles per hour
f = per-vehicle entry fee at the site.

The first term on the right side of equation [1] represents the out-of-pocket cost of driving a car from an origin to the recreation site and returning. This cost is the number of miles traveled multiplied by the variable cost per mile of operating a vehicle.[8] Fixed costs, such as insurance payments or interest charges, are not considered. The out-of-pocket cost is then divided by the average number of persons per vehicle. This expresses the cost on a per-person basis to be consistent with the trips per-capita measure used for the dependent variable.

Most TCM analyses should not use the average travel costs reported by persons contacted at the recreation site as a substitute for the secondary travel cost data described above. With the zonal TCM, the travel cost used should be the average of all persons living in an origin, not just those who visited the site. Visitors may have a different perception of cost than nonvisitors. For recreation activities where specialty vehicles (4-wheel drives) are used by all the visitors, some adjustments to travel costs should be made to compensate for the additional costs of travel to the site.

The second term on the right side of equation [1] represents the time cost of a trip. The reasoning behind this term is that time spent traveling also is a cost. Empirical studies of commuters indicate that people value their travel time at between 25% and 50% of their hourly wage rate (Cesario 1976). However, other research has shown that recreationists may value their travel time at the full wage rate (Smith et al. 1983). The correct figure to use for the opportunity cost of time is the subject of continuing research.

For RMM, the recommended opportunity cost of time is 50% of the hourly wage rate. The average hourly wage rate of a person living in an origin can be estimated by dividing average per-capita yearly income by 2,080, the typical number of hours in a work year. Because per-capita income includes earned and unearned income, this estimate will somewhat overstate the hourly wage rate. Dividing the reciprocal of 2,080 by 2 equals 0.00024038. Therefore, multiplying the average per-capita yearly income by 0.00024038 is equal to using 50% of the hourly

[8] *Information on the cost of operating an automobile can be obtained from the U.S. Department of Transportation (1984). The average variable cost of operating a vehicle in 1984 was about 12 cents per mile (i.e., b = \$.12).*

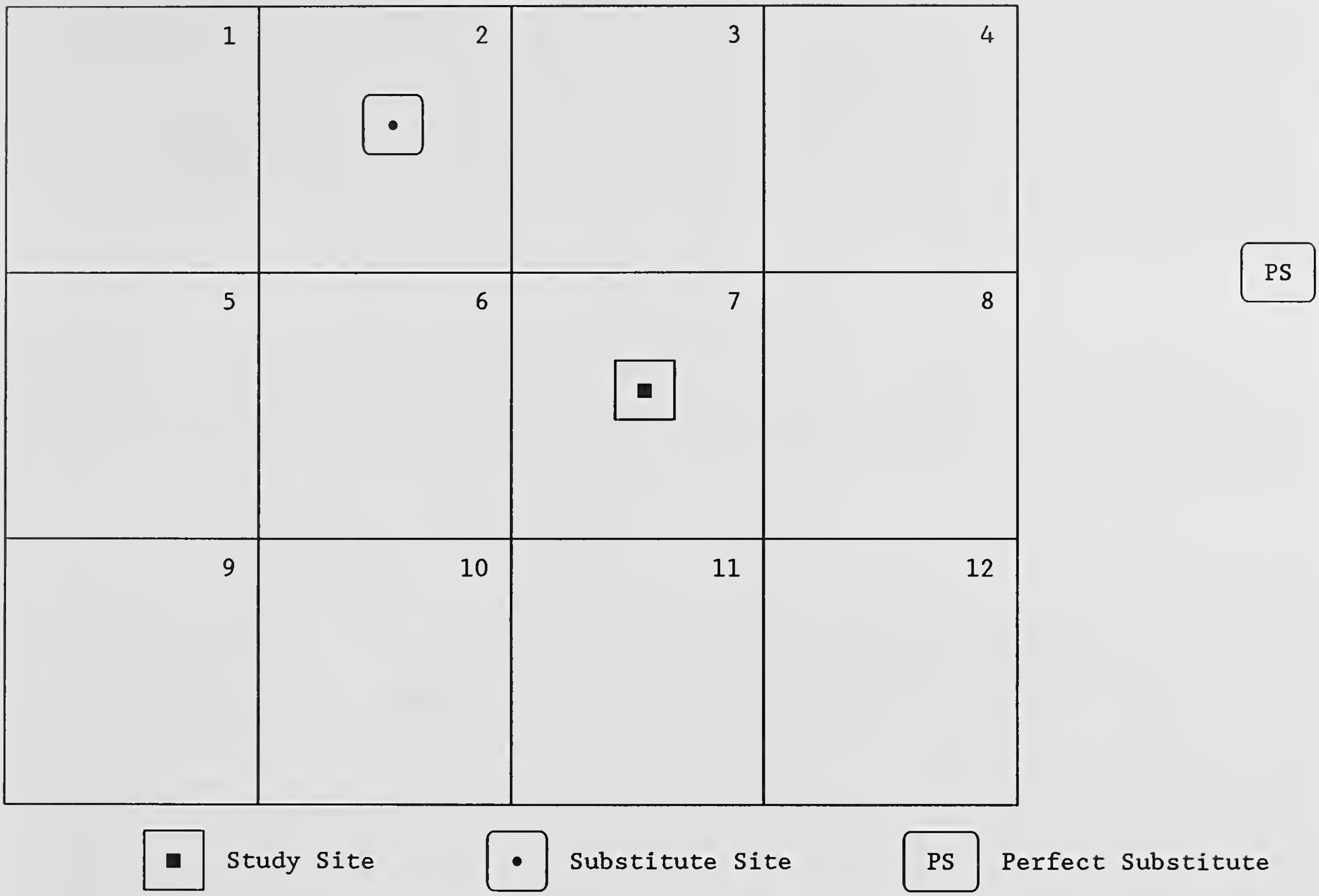

Figure 1.—Study site, substitute sites, and market area.

wage rate (as estimated by per-capita income) as the opportunity cost of travel time. The second term on the right side of equation [1] multiplies this hourly opportunity cost of travel time by the number of hours spent in travel to determine the total time cost of the travel.

The third term on the right side of equation [1] represents the per-person entry fee to the site. The sum of the time cost, the out-of-pocket vehicle-operating cost, and entry cost equals the per-person cost of a trip to the recreation site. To calculate price, information in d_i, a, b, t, f, c, and e is needed. Given that prices are derived directly from costs, the terms are often used interchangeably in TCM.

Type 3 Data: Primary, Nonessential

Two pieces of information fall into this category: (1) the length of time on-site for each trip to the recreation site; and (2) whether or not the recreation site was the only destination on the trip or one of several destinations. Time-on-site information is useful for two reasons. First, knowing this allows the analyst to express economic value on a per unit time basis (e.g., dollars per recreation visitor day). Second, the TCM assumes that the average time-on-site is the same for all origins. With time-on-site information, this assumption can be tested. If the assumption is severely violated, the data set can be segmented into separate data sets having homogeneous lengths of stay (e.g., split the data by day users versus overnight users).

TCM analysis assumes that the costs of a trip can be assigned to the study site. This is straightforward for sites in which only single destination trips are observed. Multiple destination trips occur when a person leaves home and visits the study site for recreation as part of a trip to other places, not necessarily for recreation purposes. Opinion on the treatment of multiple destination trips is divided. One school of thought argues that only single destination trips should be included in the TCM analysis, because destinations other than the one being studied produce part of the value of multiple destination trips. Basing the model only on single destination trips assumes that the multiple destination trips are not effective substitutes. Another argues that all trips to the study site should

be included if access to that site is the primary purpose of the trip. Using all trips, including multiple destination trips, accepts the weak complementarity argument that access to the site in question is a necessary condition for the trip to occur. The policy context becomes "with" or "without" the study site.

The subject is complicated, and there is no simple answer (Mendelsohn et al. 1990). In fuzzy situations, standard practice is to exclude multiple destination trips and clearly state that fact and the implied assumptions when reporting the results. When you are unable to separate multiple destination from single destination trips, you could possibly identify a local market area within which most trips are expected to be single destination. Unfortunately, the appropriate cutoff distance is likely to vary from site to site. Good judgment and familiarity with the site and its users are always helpful.

Type 4 Data: Secondary, Nonessential

Type 4 data for travel cost analysis includes information identifying the substitute recreation sites for the study site, the demographic characteristics of the origins in the market area of the site in question, and selected site characteristics describing the features of the substitutes and study sites. This information can be directly incorporated into the basic TCM (first stage demand equation), which models the number of trips per capita from an origin as:

$$VC_i = f(P_i, S_i, D_i, SC_i) \qquad [2]$$

where VC_i = trips per capita from origin i
P_i = price per person per trip to the site from origin i
S_i = a measure(s) of substitute recreation areas available to origin i
D_i = demographic characteristics of origin i
SC_i = site characteristics of recreation site.

Although the type 4 information is not required by RMM, gathering such information enhances the validity of the estimated model.

The number of trips per capita from an origin to a recreation site is often influenced by the number of alternative recreation sites offering similar recreation opportunities. When discussing substitute recreation sites, a distinction must be drawn between a perfect substitute recreation site and an imperfect substitute site. In RMM, an alternative destination is considered a perfect substitute site when two conditions are met: (1) the quality of the alternative site must equal or exceed the study site in all respects; and (2) there must be enough excess capacity at the alternative site so that the increased use that would occur at that site in the event of the closure of the study site would not deteriorate the quality enough to violate the first condition. Alternative sites that do not meet these two conditions are imperfect substitute sites. Perfect and imperfect substitute sites are handled differently by RMM.

It is not always clear which recreation sites to consider as substitutes. The simplicity of the hypothetical situation shown in figure 1 is unlikely when using actual study sites. A few guidelines might be helpful. First, a substitute recreation site is an area where users of the study site might go if the study site were no longer available for recreation. Second, there may be many substitutes to the study site. The effect of all of these substitute areas needs to be considered. Of primary importance are those offering similar recreation opportunities. One good way to reflect the influence of substitutes is to record the distance from each origin to each substitute recreation site (Burt and Brewer 1971, Cicchetti et al. 1975). Then, all the imperfect substitute distances should be entered as predictor variables in the estimated demand curve. Another way to handle multiple imperfect substitutes is to construct one or more indexes that reflect the degree of substitution possibilities available to each origin (Knetsch et al. 1976).

In figure 1, the market area is the solid rectangle enclosing the 12 origins. Most trips to the study site are drawn from within the market area. Substitute recreation sites outside of the market area are as important to the TCM as substitute sites inside the market area. A natural question is just how far outside the market area should be considered. For example, when building a travel cost model in Colorado, do substitute recreation sites in California need to be considered? There is no clear answer to this question. As a guide, find the origin within the market area that is the greatest distance from the study site. Column 5 in table 1 lists the distances from each of the origins to the study site shown in figure 1. Origins 1 and 9 are the furthest from the study site, a distance of 67 miles. Any substitute recreation sites that are within 67 miles of the market area boundary should be considered for inclusion in the TCM. Taking the network of substitute recreation sites into account is a very important part of building a TCM.

If one or more perfect substitute sites are identified, then the price (distance) of a trip from each origin to the closest perfect substitute site should be recorded. However, this price should not be entered into the demand equation in the same manner as imperfect substitute prices. Instead, the price of the perfect substitute site should be used to truncate the demand curve (Knetsch 1977). Quite simply, the price of a perfect substitute site places

Table 1.—Zonal data ready for input into RMM.

Origin zone number	Population[1]	Visits[1,2]	PCI[3]	Distance to Study site[1]	Substitute site	Perfect substitute	Other variables
1	30000	224	8000	67	30	136	–
2	9000	69	7000	42	1	106	–
3	6000	77	8100	30	30	76	–
4	9000	110	7900	42	60	47	–
5	30000	282	8800	60	42	136	–
6	12000	141	7300	30	30	106	–
7	4000	87	9100	1	42	76	–
8	12000	202	8150	30	67	47	–
9	40000	356	7700	67	67	142	–
10	3000	35	7000	42	60	114	–
11	6000	93	8100	30	67	67	–
12	14000	195	7375	42	85	64	–

[1]*Variable is required to execute RMM.*
[2]*Visits have been expanded by the inverse of the sampling fraction.*
[3]*Per-capita income.*

an upper bound on the willingness of a person to pay for the right to enter the study site. RMM has an option for truncating the demand curve. If the user is not sure if a substitute site is perfect or imperfect, RMM can run the analysis both ways.

The characteristics of an origin may influence its per-capita visitation rate. Variables to consider are per-capita income, average age, average education, and anything else that might be related to visitation rates. Per-capita income is particularly important to consider, because economic theory indicates income is an argument in a demand function.

In more general multiple site TCM models, such as regional models and pooled site models, the characteristics of the site can influence its per-capita visitation rate. Variables to consider include site quality, site congestion/crowding, and the facilities provided. Site quality and congestion/crowding are best represented by an index. Site quality ratings range from best to worst and congestion/crowding index ranges from none to capacity or overcrowded. The number and types of facilities provided are particularly important to consider because they tend to reflect the amount and type of demand. Substitute site characteristics may also influence the trips per capita to the study site. RMM is designed only for single site TCM applications.

DATA PREPARATION

The data preparation step for a zonal TCM analysis is best explained with an example. Consider the layout of origins and recreation sites shown in figure 1. The recreation site for which a TCM will be developed here is in origin number 7. The figure also includes an imperfect substitute recreation site in origin 2 and a perfect substitute site on the far right side of the figure. For the moment, the perfect substitute site will be ignored.

The main function of the data preparation step is to organize the information so that it can be used by RMM. Table 1 illustrates one way to organize the data needed by RMM. For each origin or zone, the analyst must gather information on the population, the distance from each origin center to the study site, and the number of trips from each origin to the study site. Other information useful for the analysis includes the distance to the substitute site(s), the per-capita income, and any other pertinent demographic variables of the origin that influence visitation at the study site. Table 1 shows it is 67 miles from origin 1 to the study site, 30 miles to the substitute site, and 136 miles to the perfect substitute site. Distances between origins and destinations can be measured from a map using one of the scales on a ruler. Highway mileage representing actual driving distances between origin centers and destinations is a preferred method of determining distances for TCM. The origin center of a zone can be defined by a large centrally located city in the zone, or by using published information concerning the latitude and longitude of the population weighted center of each county in the United States (U.S. Bureau of Census 1974).

Table 1 also lists the number of trips coming from each origin to the study site. Origin 1 delivered 224 trips to the study site located in origin 7. A car with two persons visiting the site represents two trips. This approach is consistent as long as the travel cost variable is in commensurate units, cost per person per trip. Customarily it is assumed that the number of persons per vehicle is constant across origins. The trips shown in table 1 have been expanded by a sampling fraction. If 10% of the trips to the study site were sampled, then only 22.4 trips from origin 1 to the study site would actually have been recorded.

FUNCTIONAL FORMS

The demand analysis in RMM uses OLS multiple regression to perform TCM with five different functional forms. These functional forms are: (1) linear; (2) quadratic; (3) semi-log (independent); (4) semi-log (dependent); and (5) double-log. The best functional form to use depends on the type of run and the particular data set.

Past experience with the TCM in demand analysis suggests that either the semi-log (dependent) or double-log functional forms are the best suited in most cases. To fit these functional forms, the data must be transformed in the appropriate manner (much like any regression program) before fitting the regression. The ensuing discussions of each functional form describe the bias associated with performing these transformations in TCM analysis. Good texts on multiple regression and data transformations in multiple regression include Draper and Smith (1981) and Kmenta (1971).

To run RMM, regardless of which functional form is used, one column of data must represent the cost of the trip from the origin to the study site, and another column must show the population of each origin. For log models where the natural logarithm of the cost of a trip is an independent variable, RMM requires both the cost and the natural logarithm of cost variables. The information on cost and population is needed to generate the economic analyses in RMM. The cost and population variable must be present in the data set, but need not be included in the regression itself.

The five functional forms are:

Linear $VC_i = \beta_0 + \beta_1 C_i + \beta_2 Z_{i1} + \beta_3 Z_{i2} + \ldots + \beta_m Z_{iz} + \epsilon_i$

Quadratic $VC_i = \beta_0 + \beta_1 C_i + \beta_2 C_i^2 + \beta_3 Z_{i1} + \ldots + \beta_m Z_{iz} + \epsilon_i$

Semi-Log Independent $VC_i = \beta_0 + \beta_1 Ln(C_i) + \beta_2 Z_{i1} + \ldots + \beta_m Z_{iz} + \epsilon_i$

Semi-Log Dependent $Ln(VC_i) = \beta_0 + \beta_1 C_i + \beta_2 Z_{i1} + \ldots + \beta_m Z_{iz} + \epsilon_i$

Double-Log $Ln(VC_i) = \beta_0 + \beta_1 Ln(C_i) + \beta_2 Z_{i1} + \ldots + \beta_m Z_{iz} + \epsilon_i$

where VC_i = trips per capita (also referred to as visits per capita), i.e., trips (visits) divided by population from origin i (i = 1,...,n)
β_j = regression coefficients (j = 0,...,m) to be estimated by RMM
C_i = per person cost of a round-trip from origin i to the site
Z_{ik} = other predictor variables used in the models (k = 1,...,z), usually per-capita income and the cost of substitute sites
ϵ = an error term
Ln ( ) = natural logarithm of variable in parentheses.

Each of these functional forms is a different way of representing the trips-per-capita relationship from an origin to the study site.

The Z_{ik} terms are perfectly flexible. For example, in the linear functional form it is possible for one of the Z_{ik}'s to be the natural logarithm of per-capita income and another to be the squared average age of an origin. The one limitation is that Z_{ik} cannot be a function of C_i. In other words, changing C_i should not change the value of any Z_{ik} terms. The Z_{ik} terms customarily include the price(s) of substitute sites, per-capita income, and other measures about the characteristics of the origins such as average age and education level. Despite the flexibility of RMM, these five functional forms are customarily used in a relatively standard way. Graphs of the five functional forms are shown in figures 2 and 3.

RMM calculates the area under the demand curve to generate the consumer surplus reported by the program. This requires the program to solve for the intercept on the price axis of the demand curve, the price at which the estimated curve predicts zero visitation from an origin. Several of the functional forms shown in figures 2 and 3 are asymptotic to the price axis or bend back away from the axis. With finite price increases, trips per capita never fall to zero. The procedure RMM uses to alleviate this problem depends on the functional form selected.

Linear

This functional form was popular in earlier TCMs mainly because of its simplicity. With a linear functional form the per-capita visitation rate is regressed on the cost of traveling from an origin to the site and on other characteristics of the origin. The Z_{ik} terms usually are not transformed. For example, per-capita income usually is used instead of the log of per-capita income. However, RMM works either way. Most empirical work shows that the linear function form does not fit travel cost data very well.

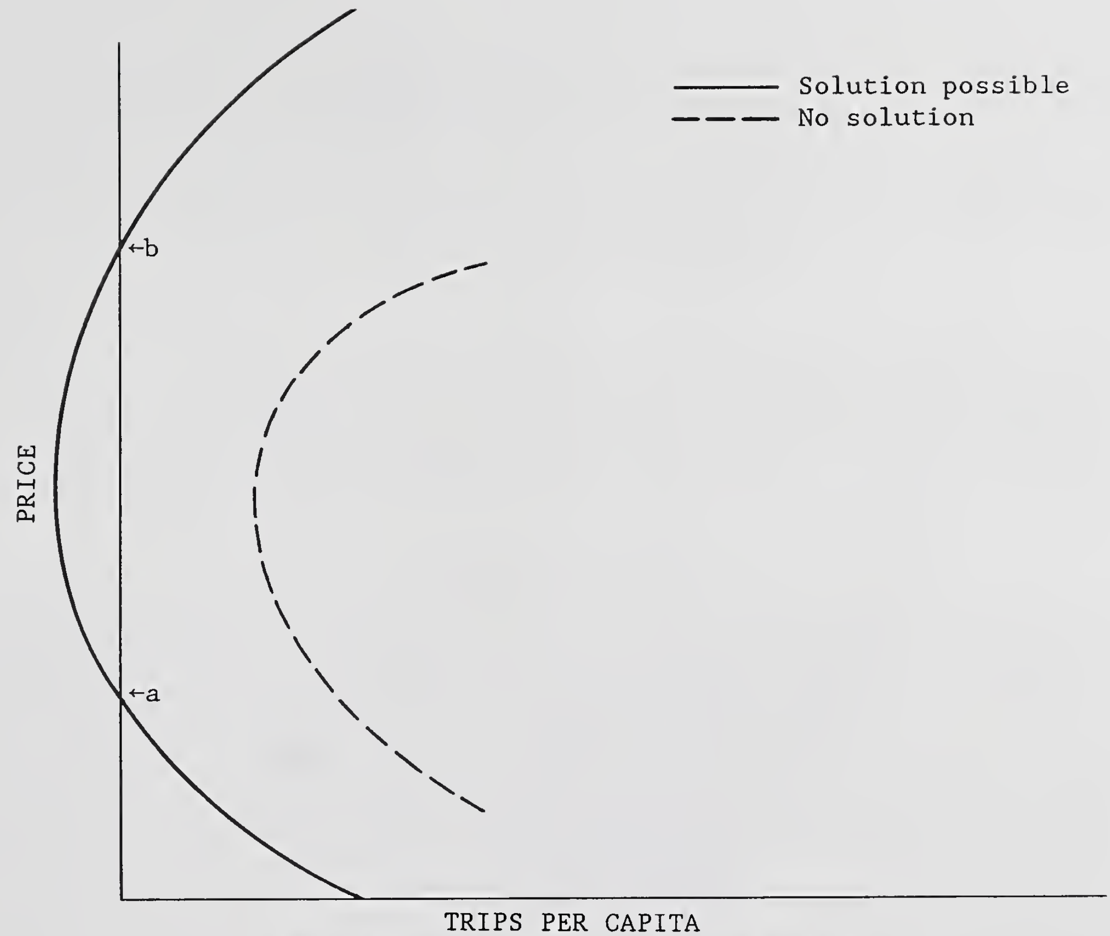

Figure 2.—The quadratic functional form for demand.

Quadratic

The quadratic functional form is identical to the linear functional form except that a squared term of the cost of traveling from an origin to the site has been added. The quadratic form is usually superior to the linear functional form for most applied travel cost models. The squared term on cost allows the estimated demand curve to bend. When using the quadratic functional form some cautions should be noted. The program assumes the β_1 coefficient is negative and the β_2 coefficient is positive. If the coefficients estimated do not have these signs, then get expert help or use a different functional form.

A further problem with the quadratic functional form is that it may never predict zero visitation regardless of the fee imposed at the recreation site. Figure 2 graphs a quadratic functional form. To generate the economic analysis, RMM solves for the cost at which zero trips from an origin are predicated (see point "a", fig. 2). In most cases there are two solutions, point "a" and point "b". The RMM program uses only point "a". However, for some data the multiple regression program in RMM might fit a curve that looks like the dashed line in figure 2. In such a case, the curve bends backwards and upwards before trips per capita is driven to zero. There is no finite fee increase that results in zero predicted visitation. This is an unreasonable model, and RMM informs the user of the problem before the economic analysis is initiated. Despite the cautions noted for the quadratic functional form, it can be quite useful in applied studies.

Semi-Log (Independent)

Like the quadratic form, the semi-log independent form also has been useful in travel cost analysis. The semi-log independent form, shown in figure 3, is asymptotic to the trips-per-capita axis and crosses the cost axis. Depending on the coefficients for β_0 and β_1, the curve can have different shapes and positions. Because it crosses the cost axis, there is a finite price associated with zero trips per capita. This is a nice property of the semi-log independent curve which is not shared by the two other log-transformed functional forms. As in the linear and quadratic model, the Z_{ik} terms are customarily not transformed.

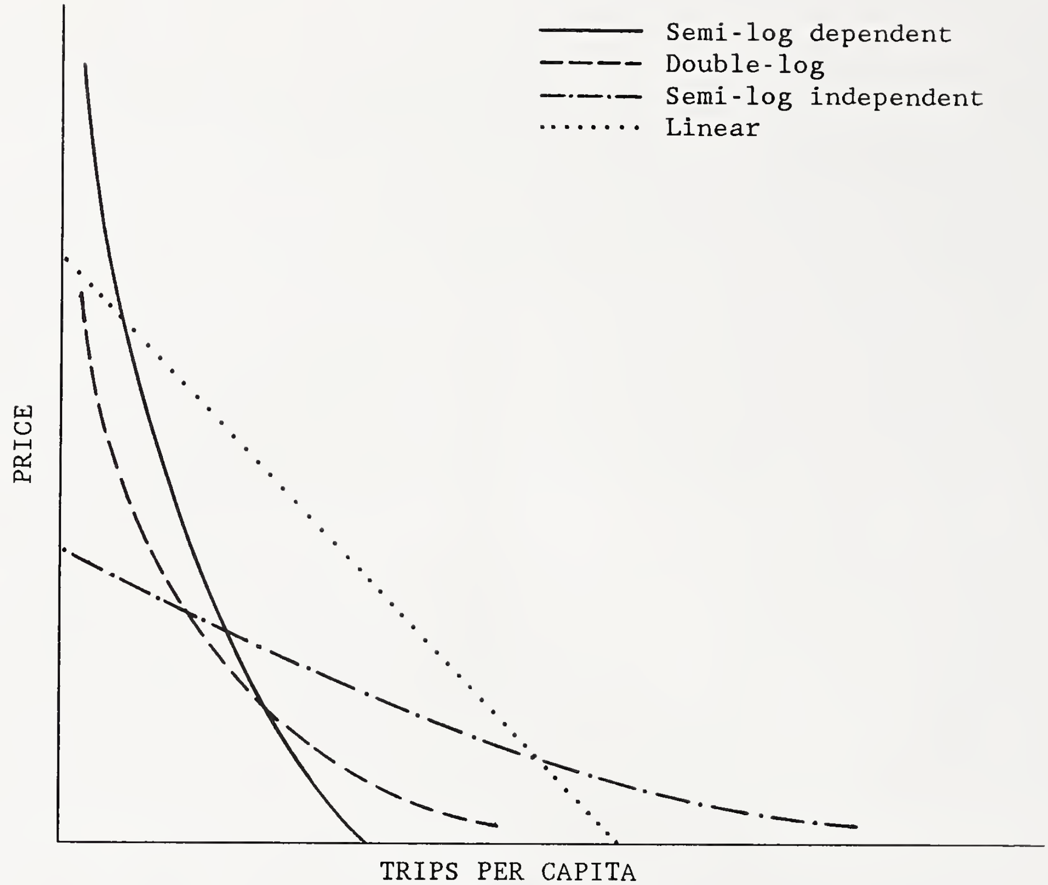

Figure 3.—Demand functional forms.

Semi-Log (Dependent)

This functional form and the double-log form are usually the ones most suited for travel cost analysis. The advantage of these functional forms is that they involve a logarithmic transformation of the trips-per-capita variable. Research has shown that the trips-per-capita variable, in its untransformed state, is heteroskedastic (Strong 1983); the variance of the residuals changes across the range of the data. The nature of the heteroskedasticity in TCM is such that the larger the value of trips per capita, the larger the residuals. Transformation of the trips-per-capita variable incorporated in the semi-log (dependent) or double-log functional forms is one way to minimize this problem. Weighted regression is another method of reducing the effects of heteroskedasticity; it has the advantage of not creating the bias problems inherent to the log-transformation method, but it suffers the drawback of increasing the difficulty of analysis. Users interested in technical treatment of heteroskedasticity are referred to any econometrics text (e.g., Kmenta 1971, Maddala 1977).

As noted above, log transformation of the dependent variable may create disadvantages. OLS on logs estimates the expected value of the log of the variable, not of the variable itself. Retransformation actually produces a biased estimate of the median, which can significantly influence the consumer surplus estimate in some cases (Stynes et al. 1986). A related problem is that by minimizing the variance of the log of the residuals, OLS operates on proportional errors on the raw variable, meaning that a residual of 500 for an observation of 1000 has the same weight as a residual of 0.5 for an observation of 1. Direct maximum likelihood estimation of the nonlinear function eliminates these problems.

The semi-log dependent functional form is asymptotic to the price axis (fig. 3). There is no finite price that predicts zero visitation from an origin to the study site. If β_1 is less than zero, the area under the semi-log dependent curve is finite. Even so, to calculate consumer surplus and graph the second stage demand curve in RMM, a finite upper bound (truncation level) on cost needs to be selected. For each origin, demand is assumed to fall to zero when the model predicts less than one trip from an origin to the site. Since the shape of the curve near the upper bound on cost can influence the consumer surplus value, the user has the choice of using the one trip rule (the default value in RMM) or of providing a new truncation level.

In this functional form, the Z_{ik} terms customarily are not transformed. Those terms appear to perform reasonably well by simply entering the price of imperfect substitute sites, per-capita income, and other measures of the characteristics of the origin.

Double-Log

The double-log functional form is doubly asymptotic (fig. 3). It does not intersect either the price axis or the trips-per-capita axis. For consumer surplus calculations, the estimated demand curve is truncated at the price it predicts one trip will go from the origin to the study site (same as the semi-log dependent). The user is provided the option of overriding the default value of one trip.

In the double-log demand curve, it is customary for the Z_{ik} terms also to be expressed using a logarithmic transformation; i.e., the natural logarithm of the price of the imperfect substitute site(s), the natural logarithm of per-capita income, etc., normally are entered as predictors into this demand equation.

RMM DEMAND PROGRAM

The following sections describe the menus and steps for building the demand (TCM) side of the market model. RMM is a menu-driven program that prompts the user at each step for appropriate responses to posed questions. The sections listed below correspond to options from the Main Menu in RMM and are presented in the order the user is most likely to follow during an initial RMM run. Users may alter the order of the program steps within the constraint of the available options offered from each menu.

Program Execution

If the RMM.EXE program file resides in a directory specified in your path, execute the program from any directory (usually your data directory) by typing RMM and pressing ENTER. Otherwise, type RMM and press ENTER from the directory in which the program resides. RMM expects a response from the user when the "?" prompt is displayed on the screen. The default response to any question posed in RMM will be enclosed in brackets, "[ ]". To execute the default response, press the ENTER key on your keyboard.

The first prompt from the RMM program is two short introductory statements. The first statement describes the relationship between RMM and its predecessor, RMTCM, and the second defines the two optional output files produced by RMM. The first optional file is a log of the RMM session documenting pertinent information about all data modifications and the results of all analyses performed during the session. This file is given an extension name of LOG. The second file stores the input data and all modifications performed during the run in a format (working array) that RMM can easily read during subsequent sessions. This TCM System File (extension name TCM) simplifies data input on succeeding RMM runs by storing the run type (demand or supply), data matrix, and all variable names assigned to specific columns of the data. RMM assigns the same default file name corresponding to the date and time of the session to each of the extensions described above. The user is given the option of renaming the file name portion to something more meaningful. RMM automatically assigns the required LOG and TCM extension names to the new file name provided by the user. The file name will always be the same for both of these files generated by RMM during the same session.

The two introductory statements are followed by the message:

```
The default name for the files with extensions LOG & TCM is...

        MMDDHHmm.LOG          WHERE:          MM = Month
        MMDDHHmm.TCM                          DD = Day
                                              HH = Hour
                                              mm = Minute

Do you wish to RENAME the .LOG & .TCM files?                  [YES]
?
```

If you wish to rename the files, press the ENTER key or "Y" (do not type the quotation marks) and provide a file name (no extension) at the prompt displayed after the statement:

```
Please enter .LOG & .TCM file name ( 8 char. max, no ext. )
?
```

Type of Run
(Main Menu Option 1)

After the preliminary steps of the program, RMM displays the Main Menu preceded by the page header which displays pertinent information about the session. Only a portion of the Main Menu is listed at this time to require

the user to define specific elements of the program before moving on. The full Main Menu will eventually be displayed after preliminary questions have been answered.

```
09-20-89                    Recreation Market Model             22:31:25
Log File: SC1.LOG               Input : Specify                 Demand: Specify
Model   : Specify                                               Supply  : Specify

                                  Main Menu

1)  Type of run                  (Demand,Supply)                [Specify]
2)  (Re)name files               (.LOG,.TCM,etc.)
99) Exit RMM

Please enter your selection from the Main Menu
?
```

Included in the header are the LOG file name, model type (demand or supply), demand and supply input data file names, the type of data input, and the form of the output. Notice the LOG file reflects the name change to SC1.LOG, renamed according to the procedure discussed above. RMM writes "specify" in a field when that particular option has not yet been defined in the current session. To exit the program at any time, enter "99" at the prompt following the Main Menu. A response of "1" at that prompt displays:

```
                         Define Run Type Menu

1) Demand run
2) Supply run
0) Return to Main Menu

Please enter number of choice from Define Run Type Menu
?
```

Since equilibrium can only be run after both demand and supply analyses have been executed during the same session, the type of run is constrained to either demand or supply. Once both have been selected and executed during the same session, RMM prompts the user for an equilibrium run. A detailed description of equilibrium is given in a later section.

The "0" option returns the user to the previous menu to start the selection process over. If a demand run (option 1) is selected, the next screen shows:

```
                  Method of Generating Coefficients Menu
                              Demand Run

1) Perform regression analysis to estimate coefficients
2) Generate your own equation (enter coefficient values)
0) Return to Main Menu

NOTE: The estimation or entering of coefficient values does not take place
      at this time. The approach selected here is executed after other
      required steps (e.g., data definitions) are completed in RMM.

Please enter number of choice from Coefficients Menu
?
```

The options provided in this menu are one of the enhancements to RMTCM. RMM requires information about the derivation or origin of coefficients used later in the economic analysis. Users of RMTCM were limited to estimation of their models in the regression package provided in RMTCM. This option is still available if "1" is selected from the menu above.

Option 2 requires estimation of the model outside RMM in another regression package or using a different form of statistical estimation (e.g., maximum likelihood). When the model is estimated elsewhere, RMM generates the economic analyses and benefit estimates for a TCM analysis. After a data set is read into RMM in the typical manner (specified later), the user defines independent variables, performs necessary transformations on those variables, selects a functional form, and provides the estimated coefficients for the parameters in the model. RMM generates

the dependent variable and performs the economic analysis. The procedure is nearly identical to the process used for a traditional estimation run using the regression option in RMM, except the user knows the values of the estimated coefficients in advance. The user is constrained to functional forms that can be transformed into one of the functional forms available in RMM. The differences between the traditional regression approach and the generate-your-own-equation approach will be noted in the relevant sections of this manual.

A third option, "0" response, from the menu returns the program to the original Main Menu. One of the first two options from the Method of Generating Coefficients Menu must eventually be selected to initialize the program. Selection of options 1 or 2 moves the program forward to the next Main Menu, where options 1, 2, 3, and 99 are displayed. Notice the type of run option reflects the selection of the demand run by listing [Demand] rather than [Specify].

Main Menu

1)	Type of run	(Demand, Supply)	[Demand]
2)	(Re)name files	(.LOG,.TCM,etc.)	
3)	Define input data	(keyboard,ASCII or TCM file)	[Specify]
99)	Exit RMM		

Naming of Program Files
(Main Menu Option 2)

Under certain circumstances it is useful to rename the files containing the results from the current analysis and working array before proceeding with the next analysis. The current contents of the LOG and TCM files can be saved under the original file name and a new file name assigned for the remaining analyses. This can be accomplished in RMM without exiting the current run. Selection of option 2 from the Main Menu allows the file name assigned to the LOG and TCM files to be changed at any time. The first prompt is activated by RMM if the current working array has not been saved on a TCM System File (see "Save Working Array"). RMM allows return to the Main Menu to perform the save:

Demand Working Array has not been saved on the TCM file.
Do you want to return to the Main Menu to save it (option 9)? [YES]
?

This option is not listed if the demand working array has previously been saved during the current RMM session. The next prompt listed by RMM asks if the current LOG file is to be saved. The LOG file must be saved if a record of the tasks already performed during the current session is desired. This is followed by a question asking the user to supply a new file name for the LOG and TCM files (8 characters, maximum length) before returning to the Main Menu. Recall that RMM automatically assigns the LOG and TCM extensions to the file name provided by the user.

Renaming the LOG output files is useful if multiple demand analyses are performed during the same RMM session and a separate record of each analysis is desired. After each analysis, select option 2, save the previous LOG file, and provide a name for the new LOG file. The same procedure can be applied to save a series of working arrays defined during the same demand session.

Define Input Data
(Main Menu Option 3)

The data input and preparation of that data for TCM analysis are the most difficult stages of RMM. To assist the user with data input, the information should be arranged like the example data shown in table 1. The cases or origins are listed as rows, and the columns define the different variables used in the model.

There is a limit on the size of the data set that RMM can accommodate. The binding constraints are:

$$(\text{Number of Cases}) \cdot (\text{Number of Variables}) \leq 8{,}000$$
$$\text{Number of Variables} \leq 50.$$

During data definition, RMM prompts for the name of each variable in the data set. The variable name can be from 1 to 8 characters in length. It is not necessary to name a variable; but it does help in interpreting the output. Whether or not the user chooses to give a variable a name, RMM assigns a default name or variable label to the variable. The default name appears in brackets as [Cnn], where nn is the column or variable number. In the exam-

ple data set shown in table 1, [C1] is assigned to the first variable (origin number), [C2] to the second variable, and so on. Either the default name, [Cnn], or the user-assigned name can be used interchangeably in subsequent stages of RMM.

The selection of option 3 from the last Main Menu shown above initializes the data input stage of RMM and displays the following submenu:

Demand Input Source Menu

1) Input data	(Interactively from keyboard)
2) Read a FILE	(An ASCII data file)
3) Read a FILE	(A .TCM System File)
0) Return to Main Menu	(To Main Menu)

Please enter your selection from Input Source Menu
?

Three options are available for loading data into RMM. If the user is familiar with ASCII data files on the PC, it is the easiest option (2) from which to initialize a first-time RMM session. Interactive or direct keyboard input of data into RMM (option 1) can be tedious and time-consuming. RMM has no facility for correcting typographical errors apart from the editing capabilities of your work station or backspacing on individual lines. You may enter a new column of data in the modify data option (see "Modify Input Data") or reenter all of the data from the beginning. Interactive data entry should only be used on small data sets. The third option (3) is provided to reanalyze a data set saved as a TCM System File from a previous RMM session. This TCM System File contains the number of cases, number of variables, variable names, and any data modifications performed before the file was saved at the user's request. The TCM System File option saves considerable time when multiple TCM analyses are expected on the same data set.

Interactive Input of Data (Menu Option 1)

A "1" entered at the prompt below the Demand Input Source Menu implies that the raw data for the TCM analysis are going to be entered interactively from the keyboard. RMM responds with:

Data will be entered from keyboard....

Please enter number of VARIABLES in each case (50 max.)
?

The number of variables referred to is the number of data elements for each case. In the example in table 1, there are seven variables (ignore the "other variables" column). These variables are origin number, population, visits, etc. In the case described, enter a "7" at the prompt. RMM proceeds to display the maximum size of the data set that it can accommodate with the number of variables the user has indicated in the preceding step.

Maximum number of cases allowed is 1143...

Name variables (up to 8 characters)
NOTE: Press ENTER for default name

Please enter name [C1]:
?

At the prompt following the maximum number of cases allowed, RMM requests names for each of the variables in the data set. Once all the variable names have been defined, RMM prompts the user for the actual data:

Keyboard input is FREE format. Use as many lines as required for each
case, but each case MUST begin on a new line.
Enter "END" to stop data input.
Begin data entry now.

Data entry is on an origin by origin basis, where all variables for one origin are entered before the next origin is started. Begin data entry for the first origin by proceeding across a row, leaving a blank space between each

variable entered. If the number of variables for each origin exceeds the number that can be input on a single line, press ENTER and continue entering data on as many lines as is necessary to accommodate all the variables. Always begin data entry for the next origin on a new line (press ENTER to start a new line). RMM uses the information on the number of variables to keep track of variables assigned to each origin. For this reason, an entry must be made for each variable. If there is missing information for a variable (e.g., per-capita income for an origin is unknown), enter an integer that can be declared later as a missing value code. Negative integers work well because they are not easily confused with nonmissing data.

To terminate data input, enter an END on a line by itself. RMM gives you the option to continue.

```
"END" entered or an illegal character entered!
Are you finished with data entry?                                    [YES]
?
```

If an "N" is entered, RMM returns to the data entry stage at the beginning of the last line entered and data entry continues until another "END" or error is detected. A "Y" prompts RMM to read the data and list the number of cases read for verification by the user.

Read ASCII Data File (Menu Option 2)

Selection of option 2 from the Demand Input Source Menu enables the user to input data from a file outside the RMM environment. RMM responds with:

```
Please enter ASCII data file name
?
```

Enter the name of the data file (include extension and path to appropriate directory, if necessary) that contains only ASCII data; RMM, at this time, cannot ready binary or EBCDIC files.

After the file name is entered, RMM requests information about the number of variables in the data file.

```
Please enter number of VARIABLES in each case (50 Max.)
?
```

Enter at the prompt the number of variables in the ASCII data file. In the example data set in table 1, "7" would be entered as the number of variables (ignore the "other variables" column). RMM responds to this entry by displaying the maximum number of cases that it can accommodate with the number of variables the user has indicated in the preceding step. Following the maximum number of cases allowed, RMM requests names for each of the variables in the data set. Recall that naming the variables is optional and RMM provides default labels for each variable, e.g., [Cnn].

After variable names have been defined, RMM needs information on how to read the ASCII data into the program.

```
Do you wish to specify an INPUT format?                              [YES]
?
```

An "N" response invokes the default format, free-field. This format requires each data value in the input file be separated by a blank and each origin to be a separate record. A positive response at the prompt causes RMM to request a format statement for the data file.

```
Enter format
?
```

The user should enter a valid F-type FORTRAN format statement enclosed in parentheses, e.g., (4F2.0,3F6.2). RMM assumes all data to be in a REAL format. Using an INTEGER format will cause an error. No syntax checking is performed on the format statement, and an execution error will result if it is not correct. RMM indicates a successful read of the data file by displaying the number of cases read.

Read a TCM System File (Menu Option 3)

Option 3 allows the use of a TCM System File created during a previous RMM session. This TCM System File contains the number of cases, number of variables, variable names, and any data modifications performed before

the file was saved. Considerable time spent on data definition is saved by using the TCM System File option. After option 3 is selected RMM displays:

Please enter name of .TCM file (include .TCM extension)
?

The user must enter the file name and extension (.TCM) of the TCM System File as it is stored in the DOS environment (include path if necessary). After the file is opened and read by RMM, summary information about the file is displayed for verification by the user. RMM prompts the user with:

Is this the correct data set? [YES]
?

If the data set is incorrect, the user is prompted to try again by entering the name of a different TCM System File.

After the data is read using any of the three menu options for data entry, the remainder of the data input questions are common to all three options. Visual verification of the data is offered by RMM through a listing of the first four and last cases of data. The user is also offered the option of listing the entire data set. Listing all the data helps verify that everything is ready and entered properly.

First 4 cases of data for variables "#" to "#" are as follows...
[...data for first four origins listed...]

Last case of data is as follows...
[...data for last origin listed...]

Do you want to list ALL the data? [NO]
?

In these listings, large or small numbers are listed using exponential notation. The sign and size of the exponent are displayed to the right of the letter E. For example, 0.13829E+06 (i.e., 0.13829×10^6) is 138,290 and -0.13829E-02 is -0.0013829.

Regardless of whether you choose to list all the data or not, RMM writes the data to the LOG file for future reference. If writing the data will fill more than one page of output, RMM lists the number of pages required and prompts to verify that the listing should be limited to only one page in the LOG file.

Writing all cases will add "#" pages to the .LOG file.
Write only the first page? [YES]
?

A "Y" response limits the list of data to one page. An "N" response instructs RMM to write out all the cases, regardless of the size of the listing.

Next, RMM displays:

Substitute MEANS for MISSING VALUES? [NO]
?

For cases with missing observations or values defined as missing, the missing data value can be replaced by the mean value of that variable computed across all cases with valid observations. An "N" response to the above question returns the user to the Main Menu. A "Y" triggers RMM to display:

Please enter value to be REPLACED (Integer)
?

The missing value code entered must be an integer number. Using an integer such as -999 as a missing data value is preferred because it is not easily mistaken for valid data. Every occurrence of that value is replaced with the mean of the appropriate variable across the valid observations. RMM proceeds variable by variable until all missing values in the working array have been transformed. The mean value replaces the missing value in all subsequent operations in RMM, including statistical analyses, and in the data array saved as a TCM System File. After the command is executed, the original missing values in the data array can only be retrieved from the original input data set.

This method of replacing missing data can produce misleading results when the amount of missing information is extensive. One way to evaluate the impact of this approach is to run the regression "with" versus "without" the substitution for missing values. Create one data set using the procedure outlined above to replace the missing values. Executing the regression without the missing observations requires development of a second data set, in which all records (cases) with missing observations are removed. Since RMM does not have any data editing capability, this data set must be created outside RMM. Execute the regression program in RMM on both data sets. If the estimated coefficients from the regressions are substantially different, the substitution approach is not recommended. Try to increase your sample size by acquiring some of the missing observations or by defining new variables for which there is complete information across the sample. Users are encouraged to avoid having any missing data, especially for any of the trip information. Nevertheless, missing data are often unavoidable.

Selection of option 3 (Define input data) from the Main Menu more than once during the same demand session causes RMM to display the Demand Input Source Menu along with the following warning message.

```
CAUTION: Defining a new set of input data will destroy the contents of the
         current Demand Working Array.
         Select "0" to return to the previous menu and continue using that
         array.
```

If you inadvertently entered the Demand Input Source Menu, RMM presents the option (0) of returning to the Main Menu for continued analysis on your current working array. Otherwise, option 1, 2, or 3 from the Demand Input Source Menu causes the current working array to be immediately overwritten by the new input working array. A discussion of how to save the current working array (Main Menu Option 9) as a RMM TCM System File in DOS is presented later (see "Save Working Array").

Data entry and verification are now complete and RMM returns the user to the full listing of the Main Menu, complete with 11 options.

```
09-20-89                    Recreation Market Model                 22:31:25
Log File: SC1.LOG                Input : ASCII                      Demand: TEST.DAT
Model   : Demand                                                    Supply  : Specify

                                  Main Menu

 1) Type of run                         (Demand,Supply)                   [Demand]
 2) (Re)name files                      (.LOG,.TCM,etc.)
 3) Define input data                   (Keyboard,ASCII or .TCM file)     [ASCII]
 4) Convert distance-to-cost            (Demand only)
 5) Modify/Add/Display data             (Add,Sub.,Div.,Mult.,etc.)
 6) Select variables                                                      [Not Selected]
 7) Select functional form              (Linear, Semi-Log, Constant, etc.) [Not Selected]
 8) Display graphs                                                        [Yes]
 9) Save Demand Working Array on .TCM file                                [No]
10) Execute regression and economic analysis
99) Exit RMM
```

Notice the page header now reflects information about the type of model, type of data entry, and the file name read during data entry. An ASCII data file, TEST.DAT, has been read into a demand run; the results of which will be stored in file name SC1.LOG. The information in brackets next to each menu option describes the current status of that option. This is the Main Menu RMM displays when the user has opted to run the regression analysis and estimate the coefficients in the model. Users who prefer to generate their own equation by entering predetermined coefficients are presented with a slightly different menu:

```
11) Enter your own coefficients, then run economic analysis
```

Option 10 is replaced by option 11 in the Main Menu. You are not given both choices. The options can be changed during the same RMM session by selecting option 1 from the Main Menu and starting the analysis over.

Conversion of Distance to Travel Cost (Main Menu Option 4)

Selection of option 4 from the Main Menu invokes the equation (see equation [1] for a description of the formula) RMM provides to convert the travel distance (miles) between an origin and the destination site to the per-person

round-trip cost of a trip between the same two points. TCM requires that the model include an independent variable that represents the cost of travel (round-trip) from each origin to the recreation site. This transformation can be accomplished using the equation provided by RMM in Main Menu option 4 (Convert distance-to-cost), by defining your own equation and performing the conversion in Main Menu option 5 (Modify/Add/Display data), or before entry into RMM. Option 4 is only available during a demand session.

Figure 4 displays a worksheet summarizing the information needed to create the distance-to-cost conversion. After option 4 from the Main Menu is selected, RMM prompts the user for this information in eight self-explanatory questions. Note that the opportunity cost of time can be any value, including zero.

```
1.  Average travel speed  ________MPH
2.  Vehicle cost per mile ________$/mile
3.  Persons per vehicle   ________
4.  Are distances one-way or round-trip ________
5.  Opportunity cost of time  ________$/hour
6.  Per vehicle entry fee at the site ________$/vehicle
7.  Name of distance variable in worksheet to convert
8.  Variable name to assign to newly created travel cost variable
```

Figure 4.—Worksheet for distance-to-cost conversion.

After the user has answered the questions related to the distance-to-cost conversion calculations, RMM displays the following:

Please enter name of VARIABLE to convert
?

Enter the name of the distance variable to convert to travel cost. For the example data in table 1, variable C5 (Distance to Study Site) is entered at the prompt. The value of C5 represents the d_i in the distance-to-cost formula. This formula is then applied to each case for C5.

The resulting cost data do not replace the data in the distance column but are appended as a new column of data. RMM applies the system variable name of Cnn and asks for a user-supplied name for the new variable.

Please enter name of NEW VARIABLE (Cnn)
?

After the distance-to-cost variable is named, RMM displays the first 4 cases before asking:

List ALL the cost values [NO]
?

All the converted distance-to-cost data are displayed when an affirmative response is entered. RMM then asks if another distance variable is to be converted with the same parameter values. This is useful if imperfect substitute sites are independent variables in the model and conversion to travel costs is needed.

Another (with SAME values) [YES]
?

The program returns to the Main Menu when an "N" is entered.

Modify Input Data (Main Menu Option 5)

RMM Main Menu option 5 allows the user to perform various mathematical transformations on the data in the current working array. RMM creates a new column of data or overwrites an existing column as a result of the transformation process. This option allows the development of a working array that can be used as data input

in the estimation of the five functional forms available in RMM. To operate properly, each functional form requires a specific set of transformations on selected variables in the model; it is not done automatically in RMM. For instance, a column of data containing trips per capita can be created by dividing trips by population. The modify option also can be used to enter a new column of data as a replacement for a column containing an error.

After the Modify/Add/Display data option has been selected, RMM displays:

Modify/Display Data Menu

1)	Add 2 columns	(First + second)
2)	Subtract 2 columns	(First-second)
3)	Multiply 2 columns	(First*second)
4)	Divide 2 columns	(First/second)
5)	Add a constant	(Column + constant)
6)	Multiply by a constant	(Column*constant)
7)	Power	(Column**constant)
8)	Natural logarithm	(LN of a column)
9)	Exponential	(EXP**column)
10)	Create new column	(User entered)
11)	Display current Working Array	(List data on screen)
0)	Return to Main Menu	(To Main Menu)

Please enter no. of choice from Modify/Display Data Menu
?

All data transformation operations in the Modify/Display Data Menu, except selection 10, act on entire columns of data. Two input columns of data are required for operations performed using options 1 thru 4, one column for options 5 thru 9, and no input columns for option 10. All transformations require the specification of an output column to store the newly created variable. The output column can be either an existing column or a new column. If the output column is an existing column, the data in that column are replaced by the transformed data. If the transformed data are stored in a new column, the new variable becomes a part of the current working data array, which is now one column larger. Occasionally it may be necessary to overwrite an existing column to avoid exceeding the 50-variable maximum. Select option 11 to display the contents, including data and variable names, of your current working array and to verify the results of new transformations.

After you select the desired transformation and identify the appropriate input columns, RMM asks about the output column.

Put results in EXISTING column [NO]
?

An "N" response causes RMM to request a variable name for the new output column. If the user opts to put the results in an existing column ("Y" response), RMM asks for the variable name of the column to be replaced and gives the user the option of renaming it. After the transformation and naming operations have been completed, the first four and last cases for the new variable are listed. RMM then asks if the user wants all the cases listed for the new variable. The program returns to the Modify/Display Data Menu where more transformations can be performed or an entry of "0" displays the Main Menu.

Selection of Variables
(Main Menu Option 6)

Main Menu option 6 is a required option in RMM for TCM analysis, whether you choose to estimate your model with regression (option 10) or to generate your own equation (option 11) estimated from other sources. RMM must be able to identify the set of variables to use in the analysis and distinguish between the independent and dependent variables. If you opt to generate your own equation, the use of the word "regression" in the program and text can be misleading. Ignore the "regression" and view the process as the selection of variables for analysis.

Before entering option 6, make sure all necessary data transformations (i.e., trips per capita, travel cost variable, and natural logs) have been completed for the functional form you plan to fit. RMM does not perform any internal transformations prior to estimation. If the data set is incomplete, return to menu options 4 or 5 and complete the working array.

Assume for now you plan to use the regression option in RMM and fit your own demand curve. A "6" entered from the Main Menu reveals the Select Variables Menu.

Select Variables Menu

1) Define INDEPENDENT/DEPENDENT variables
0) Return to Main Menu

Please enter number of choice from Select Var. Menu
?

Enter a "1" at the prompt to begin the process of selecting variables for the regression analysis. RMM lists all the variables in the current working array and prompts each variable for inclusion or exclusion from the model.

Select INDEPENDENT variables for analysis
Use "variable name"? [YES]
?

The user-defined variable name is substituted in the prompt for the label "variable name." A "Y" response or an ENTER automatically incorporates the variable into the analysis as an independent variable. Otherwise, the variable is dropped from the analysis when an "N" is encountered and the next variable in the working array is displayed. If no independent variables are selected, RMM returns to the Select Variables Menu.

After all independent variables have been listed, RMM asks:

Please enter name of DEPENDENT variable
?

Enter the name of the dependent variable at the prompt. The units of the dependent variable must be in the form **trips** (visits) **per capita** or **log of trips per capita** (depending on functional form) for the economic analysis to operate correctly. Also, the user is responsible for making sure the units on the right-hand side of the equation correctly match the units chosen for the dependent variable. Please note that the distance-to-cost conversion equation in RMM generates the travel cost variable in person-trip units as opposed to group-trips. Regardless of the units, the regression component of the program will operate correctly. However, the economic analysis is meaningless if the dependent variable is not expressed as trips per capita (or log of trips per capita) or is not matched to the units of the right side of the equation.

At this point the program lists the independent and dependent variables selected for the analysis. The next prompt asks if there are changes. If "N" is selected, the program returns to the Main Menu. RMM automatically repeats the steps in the Select Variables Menu if the user wants to change any of the variables previously selected.

The steps described above outline the procedure to identify the independent and dependent variables for estimation of a regression equation in RMM. If you chose option 2 from the "Method of Generating Coefficients Menu" and plan to use RMM to generate the equation you estimated elsewhere, these steps are correct except for the dependent variable. A dependent variable is not needed when option 2 is selected since RMM is not estimating the equation. RMM generates the dependent variable using the independent variables, the functional form, and the coefficients provided for the independent variables. RMM does not prompt for a dependent variable as part of the definition of the regression variables. Instead, RMM lists the independent variables selected above, notes that the dependent variable will be calculated rather than estimated, and prompts for verification that the correct variables have been selected:

The DEPENDENT variable is generated by your equation
Do you have any CHANGES? [NO]
?

The program returns to the Main Menu if "N" is selected. Otherwise, the steps in option 6 are repeated until a satisfactory group of variables is selected.

Select Functional Form (Main Menu Option 7)

In addition to the selection of variables to incorporate in the analysis, RMM requires the specification of a functional form (option 7) to perform the economic analyses. The functional form is necessary whether the user chooses

to perform the regression analysis in RMM (option 10) or to generate an equation (option 11) using coefficients estimated outside RMM. Estimates of consumer surplus cannot be calculated accurately unless the functional form is correctly specified. Five functional forms are provided to give the user the flexibility to fit quite general models when using RMM. Note that the functional forms refer to the relationship between the dependent variable and the independent variable representing travel cost. The Z_{ik} terms let the program account for substitute sites, demographic factors, etc., and are allowed to be transformed as the user wishes. The choice of the proper functional form is complicated (a few suggestions are given in the "Advanced Issues" appendix of this guide).

Selection of option 7 from the Main Menu displays the different functional forms available in RMM.

Select Functional Form Menu

1) Linear
2) Quadratic
3) Semi-log INDEPENDENT
4) Semi-log DEPENDENT
5) Double-log
0) Return to Main Menu

Please enter functional form used
?

At the prompt enter the number from the Select Functional Form Menu that corresponds to the functional form you wish to use in the analysis. RMM responds with several questions about variables pertinent to the economic analysis. The variables requested only have to be present in the working array. It is not required that they be defined as one of the variables selected for analysis in option 6. The first question requests the name of the variable representing the cost of travel from an origin to the recreation site.

Please enter variable name for round-trip cost
?

If a quadratic functional form is selected, an additional question asks for the name of the cost-squared variable. For the double-log and semi-log independent functional forms, RMM prompts the user for the variable names corresponding to the cost of travel and the natural logarithm of the cost of travel variables. The next prompt is displayed regardless of functional form.

Please enter variable name for population
?

Two functional forms, semi-log dependent and double-log, were earlier identified as asymptotic to the price axis. To calculate consumer surplus for these functional forms, RMM truncates the estimated demand curve to "0" trips when the model predicts less than "1" trip will go from each origin to the study site. The program solves the equation for the price at which the model predicts "1" trip from each origin. Any price above this upper bound causes the model to predict "0" trips from the origin. An "N" response to the message listed below gives the user the option to override the default truncation level of "1" trip.

1.0 is the number below which the estimated trips are set to ZERO
OK? [YES]
?

RMM requests a new level of estimated trips from which it can determine a new upper bound (truncation level) on the price variable.

Please enter new number below which trips are set to zero
?

A value smaller than "1" extends the estimated demand curve further up the price axis and generates more consumer surplus from each origin. Conversely, values greater than "1" cause a lower truncation level on price and shrink the area under the demand curve, reducing consumer surplus. The default value of "1" trip seems reasonable for most applications. It is difficult to visualize fractional trips being delivered to recreation sites.

Display of Graphs (Main Menu Option 8)

Option 8 from the Main Menu works as a toggle controlling the display of graphs in RMM. By default, graphs are displayed during a demand run for the residual analysis and for the second stage demand curve. Selection of option 8 suspends the display of graphs and changes the indicator in brackets on the line listing that option from [YES] to [NO]. Graphs will not be presented for the remainder of the analysis in that module or until option 8 is selected again and the switch is retoggled to [YES].

Save Working Array (Main Menu Option 9)

Option 9 from the Main Menu instructs RMM to save the current working array as a TCM System File with the default extension (.TCM). The file will be saved in the current directory in DOS. The file name assigned to the extension is the current file name approved by the user upon entry to the program or renamed by the user through selection of option 2 from the Main Menu. RMM saves the run type (demand or supply), data matrix of values for all variables in existence at the time the save option is executed, the variable names assigned to each column of data, and the number of cases and variables in the data set. This includes all variables created as part of transformations performed before option 9 is selected. If option 9 of the Main Menu is executed a second time for the same run type (e.g., demand) during one RMM session, the program overwrites the first file for that particular run type and replaces it with the contents of the working array in effect at the time the second save was initiated. Multiple working arrays defined for the same run type can be saved as separate TCM files during one session. After analysis is completed on one working array, execute the save (option 9) and rename (option 2) the LOG and TCM files before defining a new input data array (option 3).

Note that RMM can save the working arrays from both demand and supply runs performed during one RMM session on the same TCM System File (same file name). Option 9 must be activated independently for each working array before the RMM session is terminated (i.e., during one RMM session, save the demand array during a demand run, initiate the supply module and save the supply array during the supply run). This helps organize the demand and supply data into one input data set for subsequent equilibrium analyses. Either (or both) working array(s) can be accessed during subsequent RMM sessions by simply requesting the TCM file. A data file saved as a TCM System File can save considerable time on subsequent runs, especially if significant transformations to the data need to be performed during each RMM run.

Execute Regression and Economic Analysis (Main Menu Option 10)

If you chose option 1 (Perform regression analysis to estimate coefficients) from the Method of Generating Coefficients Menu, option 10 from the Main Menu executes the regression program and initiates the economic analysis. Option 10 is only available for a run in which the TCM model is estimated in RMM. Execution of the regression analysis requires that options 6 (Select variables) and 7 (Select functional form) be successfully completed, as indicated by [Selected] to the right of both options in the Main Menu.

Regression Summary Report

RMM produces an output of brief regression statistics in response to the selection of option 10. The brief output lists regression coefficients, t-statistics, probabilities, and R^2 for the first stage demand equation just estimated. A satisfactory TCM should have negative regression coefficients on the variable representing the cost of visiting a recreation site (note that in the quadratic model one would expect the mixed signs previously described). The coefficients for substitute prices should be positive. A negative coefficient for a substitute price variable implies complementarity with the own price. The R^2s in TCMs are usually not very high, and often range between 0.1 and 0.5. The R^2 from the semi-log (log-dependent) and double-log function form is not comparable to the R^2 from the other three functional forms. Stynes et al. (1986) discuss comparisons between travel cost models estimated with and without logarithmic transformations. Much has been written on how to select the best regression model (Draper and Smith 1981, Kmenta 1971). The R^2, t-statistics, and theoretical reasonableness are all factors that go into selecting the final model.

Listed just below the output summarizing the coefficients in the model is an analysis of variance summary table followed by a prompt to continue. After you have finished inspecting the regression results, press ENTER for

the plot of residuals. Specifically, the residuals are plotted against the predicted value of the dependent variable from the regression analysis.[9]

Economic Analysis

Below the residual table, the program automatically moves into the economic analysis with the message:

A fee INCREASE of "$$$$.$$" results in ZERO trips from all origins
The last origin to produce trips is "Number of Origin"

The first line shows how much of an increase in trip cost (i.e., fee increase at the site) is needed to drive visitation from all the origins to the study site to zero. For example, let

$$VC_i = f(C_i, S_i, Z_i) \quad [3]$$

represent the functional form the user has fit with multiple regression. Then, the predicted visitation at a given fee increase, ΔC_i, is

$$VC_i(\Delta C_i) = f(C_i + \Delta C_i, S_i, Z_i). \quad [4]$$

The fee increase needed to drive trips to zero for a given origin i is

$$0 = f(C_i + \Delta C_i^*, S_i, Z_i). \quad [5]$$

The fee increase reported in RMM is the maximum ΔC_i^* and represents the largest fee increase required to drive trips to zero from all origins. The origin or case number associated with the maximum is also reported.

Following the report of the maximum fee increase required to generate zero trips from all origins, RMM prints a note about demand cutoff points and asks whether or not cutoff points are to be used in the economic analysis.

NOTE: Demand cutoff points are applicable only to models
containing at least one perfect substitute site.

Invoke demand cutoff points option [NO]
?

Typical TCM models do not incorporate demand cutoff points in the economic analysis. Demand cutoff points relate to the issue of substitute recreation sites and should be entered only if a perfect substitute site to the study site has been identified. A perfect substitute site is one that offers the same recreation opportunities at an equal or higher quality level than the study site, and has sufficient capacity to handle the increased use that would result if the study site were closed. Since the perfect substitute is considered the same commodity as the study site, inclusion of the price term for a perfect substitute in the demand equation is contrary to economic theory and creates difficulty with the interpretation of the results from estimation. RMM incorporates perfect substitute sites in the economic analysis using the demand cutoff point option. The price of a trip from an origin to the closest perfect substitute site is the "demand cutoff" point for that origin. (The application of the demand cutoffs option is explained in the appendix, "Advanced Issues.") For now, respond to the cutoff points prompt as if there are no perfect substitute sites in your model.

After addressing the inclusion of cutoff points, RMM requests the number of fee increments to be used in generating the second stage demand curve.

The default number of fee increments is 21.
Is 21 OK? [YES]
?

The default number of 21 is used unless the user requests more increments (100 maximum) after responding "N" to the prompt. A larger number of fee increments provides a clearer graph of the second stage demand curve and, in some cases, increased accuracy for the estimates of consumer surplus. Since RMM employs numerical integration to calculate the consumer surplus, an increase in the number of data points can increase the accuracy of the calculations, especially for functional forms generating second stage demand curves that are highly curvilinear.

[9]Readers not familiar with how to interpret residual plots are referred to any statistics text that discusses their interpretation (Draper and Smith 1981).

A summary report is listed after the number of fee increments has been specified. The first part of the summary report is a table showing various simulated fee increases at the site and how many trips would occur at the site if each of those fees were charged. A fee increase of zero reflects the existing condition. The predicted number of trips at the zero fee increase should be reasonably close to the actual number of trips now occurring at the site. If the predicted number of trips deviates substantially from the observed number, there may be linear bias in the equation. Such linear bias is a common consequence of using OLS with log transformation of the dependent variable. For information on the cause of this bias and how to correct it, see Peterson and Stynes (1986). For large deviations, it is advisable to correct the equation outside RMM and reenter the revised parameters into RMM.

Moving down the fee increase table illustrates how simulated visitation falls as fees are increased. The RMM program automatically calculates the upper bound of the fee increase (maximum of ΔC_i^* from equation [5] above) and scales the increases between zero and the upper bound. At the upper bound of the predicted fee increases, the table should show zero, or very close to zero, trips.

The predictions of visitation at various fee increases are generated under the assumption that fees would be increased at the study site and held constant at all other sites. For example, if the study site has four substitute sites, RMM assumes that the prices of trips to the substitute sites would remain constant when fees are raised at the study site. This is unlikely if there is an agency-wide or region-wide decision to raise entrance fees. The model cannot predict what would happen to visitation in the face of a system-wide increase in fees.

Continuing under the assumption of no perfect substitute site(s), the next part of the report is a graph of fee increase versus total trips from the summary table. In the travel cost literature, this is known as a "second stage" demand curve. If one is willing to accept the assumption that travel cost dollars have the same meaning to visitors as gate fee dollars, the second stage demand curve predicts the number of trips that different levels of fee increase will produce at the site. Underneath the graph is an estimate of the total consumer surplus at the recreation site and the consumer surplus per trip. The total consumer surplus is the area under the second stage demand curve, and represents the net economic benefit to the consumer of engaging in recreation at the study site. This is an estimate of the willingness of recreationists to pay for access to that recreation site over and above their existing expenses. The consumer surplus per trip is the total consumer surplus value divided by the predicted number of trips at a zero fee increase. It is the average net willingness to pay for a trip.

The total consumer surplus measure provided by RMM in the demand analysis does not reflect the costs of supplying the recreation facility to the public. The net benefits of the recreation site to society is consumer surplus minus the costs of providing the site (see the Equilibrium Analysis section for consumer surplus net of supply costs). Any fees collected by the provider should be calculated as a benefit to the supplier and a cost to the consumer when calculating net benefit to society.

Following the output of the consumer surplus estimates, RMM asks:

Do you want the revenue analysis? [YES]
?

In the revenue analysis, the fee increase is multiplied by the estimate of visitation at that fee increase to determine the additional revenue generated by the implementation of the fee increase at the recreation site. These calculations of revenue are over and above the base revenues that are currently collected as gate fees at the site. For the revenue analysis, RMM displays a table showing the fee increases (Additional Fee), the estimates of visitation (Total Trips), the total revenue generated directly from each fee increase (Additional Revenue), and the amount revenue changes from one fee increase level to the next (Change in Additional Revenue).

Since the revenue analysis in RMM does not include base fees, public agencies currently charging an access or gate fee, and considering an additional fee, can calculate total revenue by summing the base revenue generated from existing gate fees (existing fee multiplied by the estimated visitation) with the revenue generated from a fee increase (from the table in RMM). The base fees must be calculated outside RMM at the estimated level of visitation. It is important to keep the units commensurate between the two sums involved in the computation of total revenue. For example, if the estimated trips generated from the second stage demand curve are in person-trips and the current gate fees are charged on a group or a vehicle basis, the gate fee applied to the base revenue calculation must be adjusted to a person basis before multiplying by the estimated trips. In this example, information about the current gate fee and the average number of people per vehicle are needed before the base revenue and total revenue calculations can be made.

Enter Your Own Coefficients, Then Run Economic Analysis (Main Menu Option 11)

One of the enhancements incorporated in RMM is the flexibility to estimate coefficients for a TCM model outside the RMM environment and import that model into RMM to generate estimates of consumer surplus using the economic analysis portion of the package . This option in RMM requires the same sequence of steps, in terms

of data definition, identification of independent variables, and functional form selection, as are required to estimate coefficients using the regression feature in RMM. The use of outside coefficients to generate dependent variables for first stage demand equations in RMM is constrained to TCM models that can be transformed into one of the functional forms available in RMM. This application of RMM requires a thorough understanding of travel cost analysis, and sufficient mathematical skills to transform equations estimated in other programs to functional forms appropriate for use in RMM.

Select option 11 from the Main Menu to generate your first stage demand equation from input coefficients and run the economic analyses. This option is only displayed in the Main Menu after selection of option 2 (Generate your own equation) from the Method of Generating Coefficients Menu. Options 10 (Execute regression and economic analysis) and 11 (Enter your own coefficients, then run economic analyses) are mutually exclusive and cannot be selected during the same demand session. RMM displays only one of these options at a time during a particular demand session. Option 11, like option 10, requires selection of the independent variables (option 6) and the functional form (option 7) before analysis can begin. Successful completion of these steps is indicated in RMM by [Selected] to the right of the options displayed in the Main Menu.

One way to develop familiarity with this particular option is to perform a traditional travel cost analysis using the regression analysis (option 10) in RMM. Return to the Main Menu after that run and select option 1 to start a new demand run. Perform the second TCM analysis by selecting the option to Generate your own equation (option 2 from the Method of Generating Coefficients Menu). Input the same data, identify the same set of independent variables, and select the identical functional form. Select option 11 from the Main Menu and follow the instructions outlined below to input the coefficients estimated in the previous demand run. The second stage demand curve and the estimates of consumer surplus should match those produced from the first analysis.

Generate the First Stage Demand Equation

To generate your own demand equation, RMM requires values for the predetermined coefficients (estimated outside RMM) assigned to each of the independent variables selected for analysis. These coefficients are applied to the independent variables to generate the dependent variable in the first stage demand model. For the economic analysis to function properly, RMM requires the units of the dependent variable to be in **trips per capita** (i.e., visits per capita). The user is responsible for adjusting the units on the right-hand side of the equation to match this specification of trips per capita. Depending on the functional form selected, most of the adjustments can be accomplished by manipulation of the constant term, the cost of travel variable, or one of the coefficients. Consistent with all TCM analysis, the units assigned the cost-of-travel variable must be commensurate with the units of the dependent variable.

The methods for entering coefficients are displayed in response to option 11 from the Main Menu.

```
                    Enter Coefficients Menu

1) Enter your own coefficients
2) Modify existing coefficient(s)
3) Display and use existing coefficients
0) Return to Main Menu

Please enter number of choice from Coefficients Menu
?
```

Enter a "1" to begin the process of generating your own first stage demand equation. Use option 1 when you are entering coefficients for the first time during a particular RMM session. The other options are for making adjustments to the coefficients or performing successive runs during the same session. In response to the "1", RMM requests the value of the constant term and the value of the coefficient for each variable selected previously as an independent variable (option 6) in the model. The values you input are listed for your review, followed by the prompt:

```
Do you have any corrections?                                  [NO]
?
```

Enter a "Y" to correct one or more of the values listed. An "N" is followed by the display of the regression statistics and analysis of variance table described in the section, "Execute Regression and Economic Analysis." In this context, only the coefficients have meaning since the actual regression analysis was not performed. The other sections in the table have been labeled "N/A" to inform the user that those statistics are not applicable to the method of analysis selected. The graphing of residuals is also suspended.

Economic Analysis

In response to a prompt to continue, RMM immediately performs the economic analysis. The procedures used to generate the estimates of consumer surplus are exactly the same as those described in the "Economic Analysis" section under "Execute Regression and Economic Analysis."

Following completion of the economic analysis, RMM offers the option of running that analysis a second time with a different set of coefficients. This provides a mechanism for performing sensitivity analysis on the consumer surplus estimates in response to changes in the coefficients. If further analysis is desired, respond "Y" to the following question:

```
You may change your coefficients and run the economic analysis again.
Do you want to do so?                                                [YES]
?
```

Otherwise, an "N" response returns you to the Main Menu. If you choose to rerun the economic analysis with the same set of independent variables and same functional form, answer "Y", to which RMM redisplays the Enter Coefficients Menu previously listed. From that menu, select option 1 to input a whole new set of coefficients. Option 2 allows the modification of one or more of the values entered for the coefficients. Option 3 relists the coefficients used in the previous analysis and runs the economic analysis a second time.

Exit RMM
(Main Menu Option 99)

The current demand run can be terminated by selecting options 1 or 99 from the Main Menu. Option 1 allows the user to start a new demand run or initiate a supply run without exiting the current RMM session, while option 99 exits RMM to DOS. When option 1 is selected after a successful demand run, RMM displays the following message to allow a return to the Main Menu in case option 1 is selected inadvertently or other operations are desired on the current demand working array:

```
CAUTION: If you have not yet SAVED the current Demand Working Array on a
         .TCM file and wish to do so (or if you wish to modify or perform other analyses on it), you must
         return to the Main Menu and do
         so now.

         Regardless of your choice, RMM stores the results of your Demand
         analysis for an Equilibrium analysis, if one is desired.

Do you wish to return to the Main Menu?                              [YES]
?
```

Return to the current demand run with an ENTER or a "Y" response. An "N" response causes RMM to stop the current demand run and to display the Define Run Type Menu in preparation for a new demand or supply run during the current RMM session.

If the current demand working array has already been saved on an external TCM System File (option 9 from the Main Menu), there is no reason to go back and resave it a second time. Once option 9 has been selected, the TCM file will be saved in the default directory in DOS.

Results from the current demand run are automatically stored in RMM to facilitate an equilibrium analysis when the most recent demand run is successful (producing summary tables, graphs, and consumer surplus estimates). Demand runs that generate error messages do not produce results, are not stored for equilibrium analyses, and do not print the message (shown above) regarding the storage of the results from the demand analysis.

To leave the demand module and exit the RMM session, select option 99 from the Main Menu. If the demand working array has not been saved on a TCM System File (option 9 from the Main Menu) when option 99 is selected, RMM allows return to the Main Menu to perform the save:

```
Demand Working Array has not been saved on the .TCM file.
Do you want to return to the Main Menu to save it (option 9)?        [YES]
?
```

Recall that RMM saves the working array with the current set of variables and values, including all new variables created during transformations in RMM. For example, if means were substituted for missing data on the initial data input step, the substituted mean values are saved on the TCM System File. If option 9 is not selected before terminating a demand run, the current demand working array will not be saved on the file with TCM extension.

Either an "N" response to the question listed above or the selection of "99" from the Main Menu when the demand working array has been saved, causes the following prompt to be displayed:

```
Are you sure you want to exit now?                                    [YES]
?
```

Return to the Main Menu with an "N" or respond "Y" to continue on to the next question:

```
Save .LOG file                                                        [YES]
?
```

A "Y" response automatically saves an exact duplicate of what occurred during the RMM session on a file with extension LOG. This file was named in the first step of the session or renamed using option 2 from the Main Menu. Regardless of the response to this question, the RMM session will be exited and the DOS prompt will appear.

SUPPLY ANALYSIS

The supply side of outdoor recreation is not well understood, and the reader should be very cautious when estimating supply functions with RMM. The supply function used in RMM must describe the relationship between the site operator's marginal cost and the number of visitors using the site. Marginal cost data appropriate for supply function estimation is not easily acquired, and the user should resist the temptation to use inappropriate data. For a more complete discussion of supply analysis, refer to Sinden and Worrell (1979), Freeman (1983), Nicholson (1985), and Walsh (1986).

RMM provides three options for supply analysis. The first employs the OLS regression feature in RMM to estimate the marginal cost function on user-supplied data. The second option requires input of the parameters of a supply function estimated or determined outside RMM, such as by production function analysis. User-supplied data are combined with the values of the parameters to generate the supply curve in RMM. Externally determined supply functions must have (or be transformable to) one of the standard functional forms offered by the supply module. The third, which is a special case of the second, is to specify either a horizontal (constant marginal cost) or vertical (fixed capacity) marginal cost function. In either case the user provides the constants that fix the marginal cost at the desired level.

There are two basic ways to derive a supply function. One is to develop a production function through engineering analysis. The production function describes the quantity of the good that can be produced with various combinations of the input factors. Given the prices of the input factors, the marginal cost function can then be derived analytically. In simple terms, this approach consists of deriving the cost function from knowledge of the production process.

Daniels and Cordell (1989) apply statistics and economic theory to extend the production function approach employed by the engineering analysis. Supply functions are estimated for recreation activities on USDA Forest Service lands by applying duality theory, whereby the cost function is derived by minimizing factor input costs given an output level. This cost function can be linked to the production process through its dual solution—maximum output subject to a budget constraint. The strength of this approach is that the supply functions are derived from the basic production relationship linking factor inputs and product outputs.

The second, more direct approach relies on observations of the costs generated in the production of different levels of output. Cost information available from recreation sites is not usually in the form of marginal costs, required by RMM for the execution of the supply module. Most studies documenting the costs of providing recreation opportunities use total cost data as the basis for estimation (Daniels 1987, Daniels and Cordell 1989, Gibbs and van Hees 1981). Once the parameters of the total cost function are estimated, the marginal cost function can be derived analytically. Ideally, the cost data are obtained from a single site (i.e., the study site) operating at different levels of production within a given capacity. Only rarely is such variation available for observation at outdoor recreation sites. In practice, the data required for estimating cost functions are obtained from a cross section of recreation sites operating at different levels of output. Unfortunately, the development of supply functions from cross-sectional data is complicated by the variability in production capacity that occurs between sites and by the efficiency of each of the operations. Even so, these are often the only data available from which marginal cost functions can be derived.

Gibbs and van Hees (1981) provide a framework for estimating total cost functions for recreation opportunities provided at public campgrounds. A general model of total cost for a recreation site is of the form:

$$TC = f(T,S_k) \qquad [6]$$

where TC = total cost of providing recreation opportunities at the site
T = quantity of trips provided at the site
S_k = a k-dimensional vector of other predictor variables, including site characteristics, site quality, congestion, etc.

The specific kinds of costs that are often included in the specification of the dependent variable (TC) are discussed later. Once the parameters are estimated for equation [6], the marginal cost equation is derived analytically by taking the first derivative of total cost with respect to the quantity of trips provided.

$$MC = \frac{\partial f(T,S_k)}{\partial T} \qquad [7]$$

where MC = marginal cost of providing recreation opportunities at the site.

The supply function required for input to RMM is the inverse of the marginal cost equation specified above. Solve equation [7] for the quantity of trips provided as a function of the marginal cost and other predictor variables. This yields a supply function compatible with the input requirements of RMM.

$$T = g(MC,S_k) \qquad [8]$$

Both approaches outlined above require the cost functions to be estimated using statistical packages outside RMM. RMM does not have the analytical capabilities to derive marginal cost equations from total cost equations or to invert the marginal cost equations. Once the supply function is in the appropriate form (equation [8]), the parameter values can be input directly to RMM using the option provided to define your own supply model. If data were available on marginal costs as opposed to total costs, the supply equation could be estimated directly in RMM using the multiple regression option.

DEFINITION OF SUPPLY VARIABLES

The primary/secondary and essential/nonessential framework for classifying the data requirements on the demand side will not be extended to supply. At this time, recreation supply analysis has not progressed as far as demand analysis and is not as conducive to that kind of categorization. Furthermore, most existing empirical studies focus on questions pertaining to the kinds of costs to include, rather than convenient ways to classify the costs. Because this document is by no means intended as a primer for recreation supply analysis, only a brief discussion of supply data is included. Anyone attempting to estimate supply functions is strongly encouraged to review the pertinent literature.

The estimation of a supply function in RMM requires joint observations of at least two variables: (1) the number of trips to a site, and (2) the marginal costs incurred to provide recreation opportunities at the site. Information on site use is much more readily available than the marginal cost data. Recreation participation at most public sites is tracked by actual counts or by applying techniques for estimating recreation use. Problems arise with the recreation use data when the units of the supply analysis must be both commensurate with the units developed for demand and appropriate for the types of costs used for supply. Transformations are often necessary to convert the use measures to a common metric.

Whether or not RMM is used to estimate the parameters of the supply function, the identification and acquisition of cost data is the primary concern with recreation supply. Cost information appropriate for supply analysis is difficult to obtain, especially for areas managed by the public sector. Reiling et al. (1983) overview some of the methodological issues involved with studies on the cost of provision and discuss the acquisition of cost data by disaggregating cost into three components: (1) operation and maintenance costs; (2) capital improvement costs; and (3) opportunity costs of land. The cost variable appropriate for analysis is the sum of these three cost components. Each should be calculated so that the time frame of the analysis is consistent among the three costs and with the variable representing total recreation use. Usually an annual basis is adopted.

Operation and maintenance costs relate directly to the annual costs of providing the recreation opportunities at the site. Some of the major costs in this category include labor, equipment, supplies, natural wear, and administrative overhead.

The capital or facility costs comprise a major component of the overall costs. Costs associated with the improvement or replacement of recreation sites include those incurred from building roads, trails, structures, etc. Costs from these activities are adjusted to an annual basis through amortization of the total capital costs across the life of the facility.

Opportunity costs are often the most difficult to evaluate and obtain. Land devoted to or reserved for a specific resource use has an opportunity cost measured in terms of the value of alternative uses forgone by the reserved use. The value employed as the opportunity cost is often the highest valued use of the land among the alternatives. Land ownership is one of the principal factors in identifying the set of alternative uses to consider in calculating opportunity costs. For example, an analysis designed to evaluate whether a campground in private ownership should be closed has a different set of alternative uses to consider than the same decision on land controlled by the USDA Forest Service. Assuming that the particular parcel of land managed by the USDA Forest Service must remain in public ownership, that agency need only consider the value of other appropriate resource uses (grazing, timber, etc.). The private operator has those options to consider and also the opportunity cost of selling the land for competing uses in the private sector that are not allowed on public land. Reiling et al. (1983) suggest that in some cases the opportunity cost to the public agencies is zero, as when land obtained through private donation carries restrictions requiring the public agency to manage it for a specific use, say recreation. This is one of several examples described by Reiling et al. (1983) in their overview of the important factors to consider in the assignment of opportunity costs.

In the development of the cost variable, it is important to include only those capital and opportunity costs that vary within the context or scale of the analysis. One distinction is short-run versus long-run supply analysis. For example, many types of capital costs (e.g., building roads and structures) are only applicable to a long-run supply analysis. A fixed capacity in the short run implies that these costs do not vary with output. Capital costs that arise from depreciation of the resource from recreation use over time would be appropriate in a short-run analysis. The important point is to keep the objectives of the analysis in perspective and include only those costs that reflect the proper scope of analysis.

The recreation use and cost variables are the two variables required for minimum specification of a supply function. Other variables may or may not enter the supply relationship as independent variables. These include, but are not limited to, site characteristics and measures of site quality, congestion, and ecological damage.

Some of the problems encountered when obtaining the cost data are also relevant to data collection for the other independent variables. Observations of key variables at different levels of use are rarely generated from a single production operation. A cross section of recreation sites producing opportunities at different levels is often the only means of acquiring data with sufficient variability for analysis.

A second problem is the difficulty of obtaining on-site measurements of the features or characteristics of the resource the variables are expected to describe. The only option in many situations is to employ secondary data as an index or indicator of one or more of the variables unavailable through direct observation. For example, the total cost functions estimated by Gibbs and van Hees (1981) for USDA Forest Service campgrounds incorporate a variable that reflects five experience opportunity levels used by the Forest Service to classify campgrounds. The classification system distinguishes between the different levels according to both the degree of modification associated with the site and the amount of social interaction between campers. In terms of the independent variables suggested for supply analysis, the experience variable represents an index comprised of site quality, site characteristics, and to a lesser extent congestion.

Congestion costs are important to consider in specifying the supply function. While congestion at recreation sites is known to affect the experiences of recreation users, it remains difficult to quantify the congestion costs realized by the producer of the opportunities. Harrington (1987) presents an extensive discussion of recreation congestion, which he defines as "the loss of satisfaction experienced by the user of a facility as a result of the presence of other users." Based on the approach used to define recreation supply and demand in RMM, this definition of congestion would appear to be relevant only on the demand side. Yet, the on-site impacts of congestion are realized by the producer of recreation opportunities in terms of increased costs for security, litter, facility damage, etc. Another argument for the incorporation of congestion costs in the supply equation is that the solution is often considered a supply-side decision. Congestion can be reduced by either (or both) an increase in site fees or an expansion of the on-site recreation opportunities. It is apparent that congestion costs are an important issue in specifying both demand and supply models. While empirical studies have quantified congestion costs on the demand side (Walsh et al. 1983), progress on the problem relative to supply has been limited to a conceptual orientation.

DATA PREPARATION

The main function of the data preparation step is to organize the information so that it can be used by RMM. Marginal cost data are required for each level of use (trips to the site). If a table is created to list all marginal costs (opportunity, maintenance, etc.) separately, the individual marginal cost values can be added together to create the final marginal cost variable using the modify data step of the RMM program.

FUNCTIONAL FORMS

Four different functional forms are used in RMM to estimate supply curves using multiple regression analysis. These functional forms are: (1) linear; (2) semi-log (independent); (3) semi-log (dependent); and (4) double-log. The best functional form to use depends on the type of run and the particular data set. To fit the different functional forms, the data must be transformed in the appropriate manner (much like any regression program) before fitting the regression.

To run RMM, regardless of the functional form selected, one column of data must represent the marginal cost of providing the recreation opportunities at the site. For log models where the natural logarithm of the marginal cost is the independent variable, RMM requires both the marginal cost and the natural logarithm of marginal cost variables. The information identifying the marginal cost variables is needed to generate the summary tables and graphs of the supply curve. RMM requires these variables be present in the data array for the log model described above, even though the untransformed marginal cost variable might not be included as an independent variable in the regression analysis.

The four functional forms are:

Linear $$T_h = \alpha_0 + \alpha_1 MC_h + \alpha_2 S_{h1} + \alpha_3 S_{h2} + \ldots + \alpha_m S_{hs} + \epsilon_h$$

Semi-Log Independent $$T_h = \alpha_0 + \alpha_1 Ln(MC_h) + \alpha_2 S_{h1} + \ldots + \alpha_m S_{hs} + \epsilon_h$$

Semi-Log Dependent $$Ln(T_h) = \alpha_0 + \alpha_1 MC_h + \alpha_2 S_{h1} + \ldots + \alpha_m S_{hs} + \epsilon_h$$

Double-Log $$Ln(T_h) = \alpha_0 + \alpha_1 ln(MC_h) + \alpha_2 S_{h1} + \ldots + \alpha_m S_{hs} + \epsilon_h$$

where h = 1,...,n observations
T_h = quantity of trips provided at the study site
α_j = regression coefficients ($j = 0,\ldots,m$) to be estimated by RMM
MC_h = marginal cost of providing a trip
S_{hk} = other predictor variables used in the models ($k = 1,\ldots,s$), usually site characteristics or site quality, etc.
ϵ_h = an error term
Ln ( ) = natural logarithm of variable in parentheses.

The S_{hk} terms are perfectly flexible. For example, in the linear functional form it is possible for one of the S_{hk}'s to be the natural logarithm of one of the site characteristics. The one limitation is that S_{hk} cannot be a function of MC_h; i.e., changing MC_h should not change the value of any S_{hk} terms.

Each of these functional forms is a different way of representing the relationship between trips and the marginal costs of providing those trips. Figure 5 shows how each functional form might be applied to fitting recreation supply functions. Some characteristics of the functional forms are described below.

Linear

The linear functional form fits the typical textbook supply curve which increases at a constant rate. It is most useful for its simplicity, ease of interpretation, and comparability to more complex forms. The horizontal and vertical functions are special cases of the linear form, but for programming reasons, they are handled separately in the menu.

Semi-Log (Independent)

The semi-log independent functional form is asymptotic to the trips axis or, more commonly, to a line parallel to the trips axis at a positive marginal cost. Depending on the coefficients for α_0 and α_1, the curve can have different shapes and positions. Because it crosses the cost axis, there is a finite price associated with zero trips, which simplifies the calculation of producer surplus in the equilibrium module.

Semi-Log (Dependent)

The semi-log dependent functional form is asymptotic to a vertical line parallel to the marginal cost axis. With a positive coefficient on marginal cost this line is usually dependent on the value of the constant in the equation.

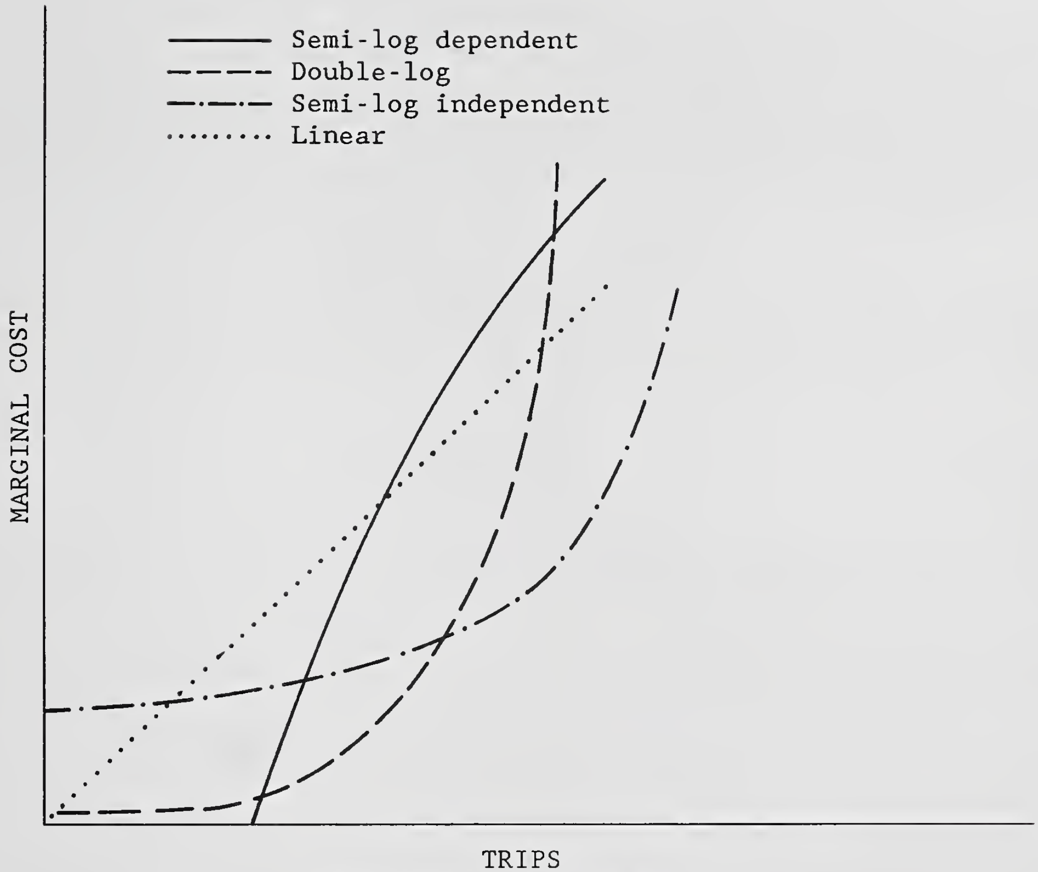

Figure 5.—Supply functional forms.

This functional form might only be useful for fitting supply curves under specific circumstances since the curve increases at a decreasing rate, whereas traditional supply curves increase at an increasing or constant rate.

Double-Log

The double-log functional form is asymptotic (fig. 5) to the trips axis when the coefficient on marginal cost is positive and less than 1. The curve approaches but never reaches the marginal cost axis as trips are decreased toward zero. Therefore, it does not intersect either the marginal cost axis or the trips axis. A coefficient greater than 1 causes the curve to acquire a shape more similar to the semi-log dependent functional form.

RMM SUPPLY PROGRAM

The following sections describe the menus and steps required to execute a supply run in RMM. It is assumed that the supply module is being run independently of demand and that the user might not have read the demand component before initiating the supply run. Many procedures performed during a supply run are identical to those described previously in the demand module. In some instances the user is referred back to the demand section for detailed information, as long as the continuity of the discussion in the supply section is not interrupted. An RMM session using both the demand and supply components will be addressed in an equilibrium section discussed later in this manual.

Most of the sections listed below correspond to options from the Main Menu in RMM and are presented in the order the user is most likely to follow during an initial RMM session. Users are free to alter the order of the program steps within the constraint of the available options offered from each menu.

Program Execution

The execution of RMM from DOS is identical for both the demand and supply modules. Refer to the "Program Execution" section of the demand module for information about the execution of RMM.

Type of Run
(Main Menu Option 1)

After the preliminary steps of the program, RMM displays the Main Menu preceded by the page header, which displays pertinent information about the session. Only the portion of the Main Menu is displayed that requires the user to define specific elements of the program. (The full Main Menu will be displayed after preliminary questions have been answered.)

```
09-20-89                     Recreation Market Model              22:31:25
Log File: SC1.LOG                 Input : Specify            Demand: Specify
Model   : Specify                                            Supply : Specify

                                  Main Menu

1)  Type of run                   (Demand,Supply)                  [Specify]
2)  (Re)name files                (.LOG,.TCM,etc.)
99) Exit RMM

Please enter your selection from the Main Menu
?
```

A response of "1" at the prompt displays the following:

```
                          Define Run Type Menu

1) Demand run
2) Supply run
0) Return to Main Menu

Please enter number of choice from Define Run Type Menu
?
```

The "0" option returns the user to the previous menu to start the selection process over. If a supply run, option 2, is selected, the next screen shows:

```
                 Method of Generating Coefficients Menu
                              Supply Run

1) Perform regression analysis to estimate coefficients
2) Generate your own equation (enter coefficient values)
3) Generate constant supply curve (vertical or horizontal)
0) Return to Main Menu

NOTE: The estimation or entering of coefficient values does not take place
      at this time. The approach selected here is executed after other
      required steps (e.g., data definitions) are completed in RMM.

Please enter number of choice from Coefficients Menu
?
```

RMM requires information about the derivation or origin of coefficients used later in the economic analysis. Menu options 1 and 2 both require the user to estimate a marginal cost function. Option 1 executes the regression analysis in RMM to estimate the coefficients for the marginal cost function as part of the supply analysis in the program. Option 2 requires estimation of the marginal cost function outside RMM, either by some statistical estimation procedure or by production function analysis. When the model is estimated elsewhere, the user reads the data into RMM in the typical manner (specified later), defines independent variables, performs necessary transformations on those variables, selects a functional form, and provides the estimated coefficients for the parameters in the model. RMM generates the dependent variable and plots the supply curve for the recreation site. The procedure is nearly identical to the process used for an estimation run using the regression option in RMM, except the user knows the values of the estimated coefficients in advance. As with the demand analysis, the user is con-

strained to functional forms that can be transformed into one of the functional forms available in RMM (see "Functional Forms" section). The differences between the traditional regression approach and the generate-your-own-equation approach will be noted in the relevant sections of the manual.

The third option in this menu is a special feature added for the supply and equilibrium analyses. Data to develop recreation site supply curves are often difficult to acquire. Option 3 allows the specification of a vertical or horizontal supply curve at user-defined levels. A horizontal MC function means marginal cost is constant, and a vertical function implies a capacity constraint. The economic ramifications of marginal cost curves taking these shapes will not be addressed here. The procedure in RMM to execute the constant supply curve, option 3, is addressed in a later section, after the basic supply analysis is presented.

A fourth option, "0" response, from the menu returns the program to the original Main Menu. One of the first three options from the Method of Generating Coefficients Menu must eventually be selected to initialize the program. Selection of options 1 or 2 moves the program forward to the next Main Menu, shown below. Notice the Type of run option reflects the selection of the supply run by listing [Supply] rather than [Specify] shown in the previous Main Menu.

```
                                Main Menu

 1) Type of run            (Demand,Supply)                        [Supply]
 2) (Re)name files         (.LOG,.TCM,etc.)                       [Specify]
 3) Define input data      (Keyboard,ASCII or .TCM file)
99) Exit RMM

Please enter your selection from the Main Menu
?
```

Naming of Program Files (Main Menu Option 2)

Selection of option 2 from the Main Menu allows the file name assigned to the LOG and TCM files to be changed at any time. The first prompt is activated by RMM if the current working array has not been saved on a TCM System File (see "Save Working Array" section). RMM allows return to the Main Menu to perform the save:

```
Supply Working Array has not been saved on the .TCM file.
Do you want to return to the Main Menu to save it (option 9)?        [YES]
?
```

This option is not listed if the supply working array has previously been saved during the current RMM session. The next prompt listed by RMM asks if the current LOG file is to be saved. The LOG file must be saved if a record of the tasks already performed during the current session is desired. The next question asks the user to supply a new file name for the LOG and TCM files (8 characters, maximum length) before returning to the Main Menu. RMM automatically assigns the LOG and TCM extensions to the updated file name provided by the user.

Define Input Data (Main Menu Option 3)

Recall that the supply analysis requires at least two pieces of information: (1) number of total trips to the study area,[10] and (2) the marginal cost per trip incurred by the supplier in providing recreation opportunities for each level of total trips. The values for these two variables should be arranged as columns in the data set. Each case or row in the data matrix has one value corresponding to a particular level of total recreation trips and a second value representing the marginal cost per trip of providing recreation opportunities for that level of trips. This simple two-variable model can be expanded to multiple variables by adding more columns to the data set.

There is a limit on the size of the data set that RMM can accommodate. The binding constraints are:

$$(\text{Number of Cases}) \cdot (\text{Number of Variables}) \leq 8{,}000$$
$$\text{Number of Variables} \leq 50.$$

[10] *The dependent variable from the supply equation is not required when the user is providing the coefficients for the cost function. RMM generates the dependent variable.*

During data definition RMM prompts for the name of each variable in the data set. The variable name can be from 1 to 8 characters in length. It is not necessary to name a variable, but it does help to interpret the output. Whether or not the user chooses to give a variable a name, RMM assigns a default name or variable label to the variable. The default name appears as [Cnn], where nn is the column or variable number. Either the default name, [Cnn], or the user-assigned name can be used interchangeably in subsequent stages of RMM.

To assist the user in structuring the data matrix, RMM recognizes three alternatives for data entry and various mathematical operations for manipulating the data, once entered. Selection of option 3 from the Main Menu shown above activates the data input stage of RMM and displays the three options available for loading data into RMM.

Supply Input Source Menu

1) Input data	(Interactively from keyboard)
2) Read a file	(An ASCII data file)
3) Read a file	(A .TCM System File)
0) Return to Main Menu	(To Main Menu)

Please enter your selection from the Input Source Menu
?

If the user is familiar with ASCII data files on the PC, option 2 is the easiest from which to initialize a first-time RMM session. Interactive or direct keyboard input of data into RMM (option 1) can be tedious and time-consuming. RMM has no facility for correcting typographical errors apart from the editing capabilities of your work station or backspacing on individual lines. You may enter a new column of data in the modify data option (see ''Modify Input Data'' section) or reenter all of the data from the beginning. Interactive data entry only should be used on small data sets. Option 3 is provided to reanalyze a data set saved as a TCM System File from a previous RMM session. This TCM System File contains the number of cases, number of variables, variable names and any data modifications performed before the file was saved at the user's request. The TCM System File option saves considerable time when multiple TCM analyses are expected on the same data set. The ''Define Input Data'' section in the demand part of this manual contains a complete description of each data input option. Refer to specific subheadings which correspond to each option from the Demand Input Source Menu. The instructions are directly applicable to a supply run. Also discussed in that section are the substitution of values for missing data and the listing of the data for visual verification of the data matrix.

Selection of option 3 (Define input data) from the Main Menu more than once during the same supply session causes RMM to display the Supply Input Source Menu along with the following warning message.

CAUTION: Defining a new set of input data will destroy the contents of the current Supply Working Array.

Select ''0'' to return to the previous menu and continue using that array.

If you inadvertently entered the Supply Input Source Menu, RMM presents the option (0) of returning to the Main Menu for continued analysis on your current working array. Otherwise, option 1, 2, or 3 from the Supply Input Source Menu causes the current working array to be immediately overwritten by the new input working array. A discussion of how to save the current working array (option 9 from the Main Menu) as a RMM TCM System File in DOS is presented in a later section, ''Save Working Array.''

One option available in RMM is to generate a supply curve from coefficients estimated or determined outside the program (option 2 from the Method of Generating Coefficients Menu). RMM assumes the coefficients have been estimated from multiple observations and those data are available for input to the supply analysis. In special cases in which the coefficients are derived from production function analysis (i.e., not estimation) or the data are not available for input, a data set will have to be created.[11] The easiest option is to generate several points from the supply equation. The minimum number of lines or cases required equals the number of input variables. Each case must include an observation for each variable. A supply run with five variables defined in the working array requires five lines or cases consisting of five values each. Recall that RMM generates the dependent variable in this approach, meaning it is not required as an input variable in the analysis. If data cannot be generated from the supply function, any data meeting the minimum size requirements will be sufficient. The actual values are not used in the supply analysis, but the program requires numbers to assign variable names and to structure the analysis.

[11] *The experienced analyst will recognize that the original data should not be necessary to generate a supply curve, only the values of the coefficients. Programming limitations imposed on this version of RMM require both data input and variable definition to guarantee the supply curve is generated correctly.*

Once data entry and verification are complete, RMM returns the user to the full listing of the Main Menu. Notice the page header shows information about the type of model, type of data entry, and the file name read during data entry. An ASCII data file, SUP.DAT, has been read into a supply run; the results of which will be stored in file name SC1.LOG.

09–20–89	Recreation Market Model	22:35:23
Log File: SC1.LOG	Input : ASCII	Demand: Specify
Model : Specify		Supply : SUP.DAT

Main Menu

1) Type of run	(Demand,Supply)	[Supply]
2) (Re)name files	(.LOG,.TCM,etc.)	
3) Define input data	(Keyboard,ASCII or .TCM file)	[ASCII]
5) Modify/Add/Display data	(Add,Sub.,Div.,Mult.,etc.)	
6) Select variables		[Not Selected]
7) Select functional form	(Linear,Semi-log,Constant,etc.)	[Not Selected]
8) Display graphs		[Yes]
9) Save Supply Working Array on .TCM file		[No]
10) Execute regression and economic analysis		
99) Exit RMM		

The Main Menu is now complete with 10 options. The information in brackets next to each menu option describes the current status of that option. This is the Main Menu RMM displays when the user has opted to run the regression analysis and estimate the coefficients in the model. Users who prefer to generate their own equation by entering predetermined coefficients are presented with a slightly different menu:

11) Enter your own coefficients, then run economic analysis

Option 10 is replaced by option 11 in the Main Menu. You are not given both choices during the same RMM run. The approach can be changed during the same RMM session by selecting option 1 from the Main Menu and starting the analysis over.

Conversion of Distance to Travel Cost

Upon return to the Main Menu after data input, notice option 4 is not available. The distance-to-cost conversion is only relevant to a demand run in RMM.

Modify Input Data (Main Menu Option 5)

RMM Main Menu option 5 allows the user to perform various mathematical transformations on the data in the current working array. RMM creates a new column of data or overwrites an existing column as a result of the transformation process. This option allows the development of a working array that can be used as data input in the estimation of the four functional forms available in RMM. To operate properly, each functional form requires a specific set of transformations on the variables in the model; it is not done automatically in RMM. For instance, a column of data containing trips per capita can be created by dividing trips by population. The modify option also can be used to enter a new column of data as a replacement for a column containing an error.

The Modify/Add/Display data option listed in the Main Menu of the supply analysis contains the same procedures as the option listed for demand (see the "Modify Input Data" section under "Demand Analysis").

Selection of Variables (Main Menu Option 6)

Main Menu option 6 is a required option in RMM for the supply analysis, whether you choose to estimate your model with regression (option 10) or to generate your own equation (option 11) estimated from other sources. RMM must be able to identify the set of variables to use in the analysis and distinguish between the independent and dependent variables. If you opt to generate your own equation, the use of the word "regression" in the pro-

gram and text can be misleading. Ignore the "regression" and view the process as the selection of variables for analysis. Before entering option 6, make sure all necessary data transformations have been performed for the functional form you plan to fit. If the data set is incomplete, return to menu option 5 and complete the working array.

A "6" entered from the Main Menu reveals the Select Variables Menu.

Select Variables Menu

1) Define INDEPENDENT/DEPENDENT variables
0) Return to Main Menu

Please enter number of choice from Select Var. Menu
?

Enter a "1" at the prompt to begin the process of selecting variables for the regression analysis. RMM lists all the variables in the current working array and prompts each variable for inclusion or exclusion from the model.

Select INDEPENDENT variables for analysis
Use "variable name"? [YES]
?

The user-defined variable name is substituted in each prompt for the label "variable name". A response of "Y" or an ENTER automatically incorporates the variable into the analysis as an independent variable. Otherwise, the variable is dropped from the analysis when an "N" is encountered and the next variable in the working array is displayed. If no independent variables are selected, RMM returns to the Select Variables Menu.

After all independent variables have been listed, RMM asks:

Please enter name of DEPENDENT variable
?

Enter the name of the dependent variable at the prompt. The user is responsible for making sure the units on the right-hand side of the equation correctly match the units chosen for the dependent variable. The regression component of the program will operate correctly, however, no matter what the form of the dependent variable. The economic analysis will not produce valid results if the units on both sides of the equation have not been adjusted properly.

At this point the program lists the independent and dependent variables selected for the analysis. The next prompt asks if there are changes. If "N" is selected, the program returns to the Main Menu. RMM automatically repeats the steps in the Select Variables Menu if the user wants to change any of the variables previously selected.

The steps described above outline the procedure to identify the independent and dependent variables for estimation of a regression equation in RMM. If you chose option 2 from the Method of Generating Coefficients Menu and plan to use RMM to generate the equation you estimated elsewhere, these steps are correct except for the dependent variable. A dependent variable is not needed when option 2 is selected since RMM is not estimating the equation. RMM generates the dependent variable using the independent variables, the functional form, and the coefficients provided for the independent variables. RMM does not prompt for a dependent variable as part of the definition of the regression variables. Instead, RMM lists the independent variables selected above (note that the dependent variable will be calculated rather than estimated) and prompts for verification that the correct variables have been selected:

The DEPENDENT variable is generated by your equation
Do you have any CHANGES? [NO]
?

The program returns to the Main Menu if "N" is selected. Otherwise, the steps in option 6 are repeated until a satisfactory group of variables is selected.

Select Functional Form
(Main Menu Option 7)

In addition to the selection of variables to incorporate in the analysis, RMM requires the specification of a functional form (option 7) to estimate the supply curve. Identification of a functional form is necessary whether the user chooses to perform the regression analysis in RMM (option 10) or to generate an equation (option 11) using

coefficients estimated outside RMM. Four of the five functional forms used for the demand analysis are available for the supply analysis. Note that the functional forms refer to the relationship between the dependent variable and the independent variable. The S_{hk} terms let the program account for other predictor variables in the model and can be transformed as the user wishes. Selection of option 7 from the Main Menu displays the different functional forms available in RMM.

Select Functional Form Menu

1) Linear
3) Semi-log INDEPENDENT
4) Semi-log DEPENDENT
5) Double-log
0) Return to Main Menu

Please enter functional form used
?

Option 2, the quadratic functional form, is not available for supply analysis. At the prompt enter the number from the Select Functional Form Menu that corresponds to the functional form you wish to use in the analysis. RMM responds with several questions to identify the marginal cost variable and to ascertain the range of the supply curve and the bounds for equilibrium analysis.

Please enter variable name for COST
?

For the purpose of determining the range of the Supply curve graph and the Equilibrium intersection, please enter the desired MINIMUM marginal cost per unit and the MAXIMUM marginal cost per unit.

Please enter minimum marginal cost per unit
?

Please enter maximum marginal cost per unit
?

The range of the plot will be "$$$$.$$" to "$$$$.$$"
Do you have any changes? [NO]
?

Next to the prompt following the first question listed above, enter the variable name assigned to the marginal cost variable in the working array. If you have chosen a functional form in which the natural logarithm of marginal cost is one of the independent variables, RMM also prompts for the name of that variable. The minimum and maximum marginal costs requested in the second and third questions are used by RMM to define the range of marginal costs on the vertical axis of the supply curve. They also are used to establish the range RMM uses to search for an intersection with the second stage demand curve, given that an equilibrium analysis is requested later in the same run. It is very important to specify a range that is large enough to include the expected intersection point with the second stage demand curve. Failure to do so causes the intersection to occur outside the range of the RMM search and precludes RMM from locating the equilibrium point. In the last question, RMM displays the range of the supply curve for verification by the user. A "Y" response returns RMM to the second and third questions for a new set of bounds for the supply curve. The Main Menu is displayed after an "N" is entered for the last question.

Display of Graphs
(Main Menu Option 8)

Option 8 from the Main Menu works as a toggle controlling the display of graphs in RMM. By default, graphs are displayed during a supply run for the residual analysis and for the supply curve. Selection of option 8 suspends the display of graphs and changes the indicator in brackets on the line listing that option from [Yes] to [No]. Graphs will not be presented for the remainder of the analysis in that module or until option 8 is selected again and the switch is retoggled to [Yes].

Save Working Array
(Main Menu Option 9)

Option 9 from the Main Menu instructs RMM to save the current working array as a TCM System File with the default extension (.TCM). The file name assigned to the extension is the current file name approved by the user upon entry to the program or renamed by the user through selection of option 2 from the Main Menu. RMM saves the run type (demand or supply), data matrix of values for all variables in existence at the time the save option is executed, the variable names assigned to each column of data, and the number of cases and variables in the data set. This includes all variables created as part of transformations performed before option 9 is selected. If option 9 of the Main Menu is executed a second time for the same run type (e.g., supply) during one RMM session, the program overwrites the first file for that particular run type and replaces it with the contents of the working array in effect at the time the second save is initiated.

Note that RMM can save the working arrays from both demand and supply runs performed during one RMM session on the same TCM System File (same file name). Option 9 must be activated independently for each working array before the RMM session is terminated (i.e., during one RMM session, save the demand array during a demand run, initiate the supply module and save the supply array during the supply run). This helps organize the demand and supply data into one input data set for subsequent equilibrium analyses. Either (or both) working array can be accessed during subsequent RMM sessions simply by requesting the TCM file. A data file saved as a TCM System File saves considerable time on subsequent runs, especially if preliminary transformations of variables are required before each RMM run.

Execute Regression and Economic Analysis
(Main Menu Option 10)

If you chose option 1 (Perform regression analysis to estimate coefficients) from the Method of Generating Coefficients Menu, option 10 from the Main Menu executes the regression program and initiates the economic analysis. Option 10 is only available for a run in which the supply model is estimated in RMM. Execution of the regression analysis requires that options 6 (Select variables) and 7 (Select functional form) be successfully completed, as indicated by [Selected] to the right of both options in the Main Menu.

Regression Summary Report

RMM produces an output of brief regression statistics in response to the selection of option 10. The brief output lists regression coefficients, t-statistics, probabilities, and R^2 for the marginal cost curve just estimated. A satisfactory supply run should have a positive regression coefficient on the variable representing the marginal cost of providing recreation opportunities. The R^2 from the semi-log (log-dependent) and double-log function form is not comparable to the R^2 from the other three functional forms. Much literature has been written on how to select the best regression model (Draper and Smith 1981, Kmenta 1971). The R^2, t-statistics, and theoretical reasonableness are factors that go into selecting the final model.

Listed just below the output summarizing the coefficients in the model is an analysis of variance summary table followed by a prompt to continue. After you are done inspecting the regression results, press ENTER for the plot of residuals. Specifically, the residuals are plotted against the predicted value of the dependent variable from the regression analysis. Readers not familiar with how to interpret residual plots are referred to any statistics text that discusses their interpretation (Draper and Smith 1981).

Generate the Supply Curve

After completing the residual plot, RMM generates the supply curve from the regression model estimated in the previous step. Supply models estimated as a linear relationship between marginal cost and quantity follow a simple procedure to generate predicted trips (dependent variable) from the estimated regression equation. Recall that the minimum and maximum values defining the range of marginal costs for the supply curve were input after the specification of the functional form (option 7, Main Menu). RMM automatically generates 21 marginal costs between the minimum and maximum values. Each marginal cost value is multiplied by the estimated coefficient and added to the constant term to generate the predicted value of the dependent variable. Multiple independent variable supply models are more complicated. Since the basic supply curve displayed in RMM is a plot in two dimensions between marginal cost and quantity, independent variables in the model other than marginal cost must be included to generate correct values for the dependent variable. When a model has been estimated with more than one independent variable, RMM provides two options to allow the inclusion of those variables in the generation of the dependent variable:

To generate a Supply Curve in two dimensions, a constant value is needed
for each independent variable, other than Marginal Cost, in the regression model. That constant may be the mean value for each
independent variable, or you may choose to enter your own value.

Listed below is the mean value for each independent variable:

NUM	COL	NAME	VALUE
#	C#	??????	XX.XX

1) Substitute mean for each independent variable
2) Enter your own value for each independent variable

Please enter your selection from the above menu
?

If you choose option 1, RMM puts the mean value of each listed variable into the regression equation to calculate the predicted value of the dependent variable.[12] Option 2 allows the user to input a specific value for each independent variable to be applied in the regression equation across all observations. In either case, the supply curve is generated across the range of marginal costs previously specified by the user.

Once the supply curve is generated, RMM displays a summary table showing the number of on-site recreation opportunities that would be provided at the 21 different levels of marginal cost. RMM automatically scales the marginal costs for the table between the extremes in the range provided by the user. At the actual observed level of marginal cost, the predicted number of opportunities provided should be reasonably close to the actual number of opportunities provided at the site. If the predicted number of trips deviates substantially from the observed number, there may be linear bias in the equation. Such linear bias is a common consequence of using OLS with log transformation of the dependent variable. For information on the cause of this bias and how to correct it, see Peterson and Stynes (1986). For large deviations, it is advisable to correct the equation outside RMM and reenter the revised parameters into RMM.

The last part of the supply analysis is a graph of the supply curve. The marginal costs are represented along the vertical axis with the level of recreation opportunities occupying the horizontal axis. The graph gives a visual representation of the curve estimated in the regression analysis and displayed in the table above. Producer surplus estimates are not provided for the supply analysis because an equilibrium price is needed to anchor the analysis on the supply curve. Consumer surplus was appropriate for the demand analysis because of the special nature of the second stage demand equation. The "0" fee increase level on the demand curve represents the current price (i.e., travel and time costs) paid by users to the site. The area under the demand curve and above that level is the consumer surplus. Producer surplus estimates are provided in conjunction with the equilibrium analysis presented in a later section of this manual.

After the site supply curve is displayed, the supply module is complete. If the current supply analysis was not part of an equilibrium run, return to the Main Menu in RMM by pressing ENTER. The user can proceed with another demand or supply run or can exit the program. If an equilibrium run had been initiated, the program automatically begins equilibrium analysis after pressing ENTER.

Enter Your Own Coefficients, Then Run Economic Analysis (Main Menu Option 11)

One of the enhancements incorporated in RMM is the flexibility to estimate coefficients for a supply curve outside the RMM environment and import that model into RMM to generate the supply curve and perform equilibrium analysis in conjunction with demand. This option is especially important for the supply analysis given the difficulty of locating marginal cost data for recreation sites and the likelihood that the marginal cost curves will be generated through differentiation of total cost curves estimated outside RMM. Recall that the use of outside coefficients to generate a supply curve in RMM is constrained to models that can be transformed into one of the functional forms available in RMM. RMM also requires the same sequence of steps, in terms of data definition, identification of independent variables, and functional form selection, as are required to estimate coefficients using the regression feature in RMM. This application of RMM requires sufficient mathematical skills to transform equations estimated in other programs to functional forms appropriate for use in RMM.

Select option 11 from the Main Menu to generate a supply curve from input coefficients estimated elsewhere. This option is only displayed in the Main Menu after selection of option 2 (Generate Your Own Equation) from

[12] *If you are generating a supply curve from coefficients estimated outside RMM and you have input arbitrary data for the independent variables, do not select the option to substitute the mean. Input a valid observation for each independent variable using option 2.*

the Method of Generating Coefficients Menu. Options 10 (Execute Regression and Economic Analysis) and 11 (Enter Your Own Coefficients, then Run Economic Analyses) are mutually exclusive and cannot be selected during the same supply run. RMM displays only one of these options at a time during a particular supply run. Option 11, like option 10, requires selection of the independent variables (option 6) and the functional form (option 7) before analysis can begin. Successful completion of these steps is indicated in RMM by [Selected] to the right of the options displayed in the Main Menu.

One way to develop familiarity with this particular option is to estimate a supply curve using the regression analysis (option 10) in RMM. Upon completion, return to the Main Menu and select option 1 to begin a new supply run. Generate the supply curve this time by selecting the option to Generate Your Own Equation (option 2 from the Method of Generating Coefficients Menu). Input the same data, identify the same set of independent variables, and select the identical functional form. Select option 11 from the Main Menu and follow the instructions outlined below to input the coefficients estimated in the first supply run. The results should match those produced from the first analysis.

Input the Supply Equation

To generate your own supply equation, RMM requires values for the predetermined coefficients (estimated outside RMM) assigned to each of the independent variables selected for analysis. These coefficients are applied to the independent variables to generate the dependent variable in the supply equation. The user is responsible for adjusting the units on the right-hand side of the equation to match the desired specification of the dependent variable. This is particularly important if an equilibrium analysis is to be performed. Depending on the functional form selected, most of the adjustments can be accomplished by manipulation of the constant term, the marginal cost variable, or one of the coefficients.

After option 11 from the Main Menu has been selected, RMM displays:

Enter Coefficients Menu

1) Enter your own coefficients
2) Modify existing coefficient(s)
3) Display and use existing coefficients
0) Return to Main Menu

Please enter number of choice from Coefficients Menu
?

Enter a "1" in response to the prompt to begin the process of generating your own supply curve. Use option 1 when you are entering coefficients for the first time during a particular RMM session. The other options are for making adjustments to the coefficients or performing successive runs during the same session and are discussed later in a section describing the looping option available in RMM. In response to the "1", RMM requests the value of the constant term and the value of the coefficient for each variable selected previously as an independent variable (option 6) in the model. The values you input are listed for your review followed by the prompt:

Do you have any corrections? [NO]
?

Enter a "Y" to correct one or more of the values listed. An "N"is followed by the display of the regression statistics and analysis of variance table (described in the section, Execute Regression and Economic Analysis). In this context, only the coefficients have meaning since the actual regression analysis was not performed. The other sections in the table have been labeled "N/A" to inform the user that those statistics are not applicable to the method of analysis selected. The graphing of residuals is also suspended.

Economic Analysis

In response to a prompt to continue, RMM immediately displays the supply summary table and the supply curve. The procedures used to generate those results are the same as procedures previously described in the subsection "Generate the Supply Curve."

Following display of the supply curve, RMM offers the option of running the analysis a second time with a different set of coefficients. This provides a mechanism for performing sensitivity analysis on the estimated sup-

ply curve in response to changes in the coefficients. If further analysis is desired, a "Y" response should be given to the following question:

```
You may change your coefficients and run the economic analysis again.
Do you want to do so?                                              [YES]
?
```

Otherwise, an "N" response returns you to the Main Menu. If you choose to rerun the economic analysis with the same set of independent variables and same functional form, answer YES, to which RMM redisplays the Enter Coefficients Menu previously listed. From that menu, select option 1 to input a whole new set of coefficients. Option 2 allows the modification of one or more of the values entered for the original set of coefficients. Option 3 relists the coefficients used in the previous analysis and runs the economic analysis a second time.

Exit RMM
(Main Menu Option 99)

The current supply run can be terminated by selecting option 1 or 99 from the Main Menu. Option 1 allows the user to start a new supply run or initiate a demand run without exiting the current RMM session, while option 99 exits RMM to DOS. (The "Exit RMM" section under "RMM Program" gives a complete description of options 1 and 99. The procedures outlined in that section can be applied directly to the supply module in RMM, providing the word supply is substituted for demand.)

CONSTANT SUPPLY CURVE

Since the main reason for adding the supply analysis to the RMM program was to perform simple equilibrium analyses of on-site recreation, an option for a simple supply curve was needed. Travel cost analysis on the demand side is significantly more advanced than supply analysis. In the absence of information on total costs or marginal costs for different levels of output, it might be possible to make educated guesses about a constant marginal cost across a certain range of output levels. Assuming that total costs are linear for a specific range of outputs, marginal costs are constant across the same range. Walsh (1986) discusses sources of cost information, etc., which could be used to estimate constant marginal costs. An option to define a horizontal supply curve at a user-specified level was added to RMM to meet this need.

The program was generalized to allow the user to specify a horizontal or vertical supply curve within the constant supply curve option. In some instances the supply component is just used to meet other objectives. Some managers might be interested in the fee increase required to achieve some percentage of the current use level (e.g., 50% of current use). In conjunction with the demand analysis, a vertical constant supply curve could be input at 50% of current use and the equilibrium analysis used to determine the fee increase necessary to drop use to that level. The consumer surplus realized as a result of that fee increase would also be provided.

Type of Run
(Main Menu Option 1)

Preliminary steps in the initiation of a constant supply curve run use the same procedures as those described in the section "Program Execution" under "RMM Demand Analysis." After the preliminary steps are complete, enter a "1" (Type of Run) in response to the prompt from the Main Menu and enter the Define Run Type Menu. Select option 2 to specify a supply run and wait for RMM to display:

```
              Method of Generating Coefficients Menu
                          Supply Run

1) Perform regression analysis to estimate coefficients
2) Generate your own equation (enter coefficient values)
3) Generate constant supply curve (vertical or horizontal)
0) Return to Main Menu

   NOTE:  The estimation or entering of coefficient values does not take place
          at this time. The approach selected here is executed after other
          required steps (e.g., data definitions) are completed in RMM.
```

Please enter number of choice from Coefficients Menu
?

Options 1 and 2 were discussed previously in the supply analysis. To generate a constant supply curve, select option 3. RMM responds with a Main Menu designed specifically for the constant supply curve option:

Main Menu

1)	Type of run	(Demand,Supply)	[Supply]
2)	(Re)name files	(.LOG,.TCM,etc.)	
7)	Select functional form	(Linear,Semi-log,Constant,etc.)	[Not Selected]
8)	Display graphs		[Yes]
11)	Enter your own coefficients, then run economic analysis		
99)	Exit RMM		

Several steps are omitted from the process because data input and variable definition are not necessary. Option 9, Save Supply Working Array on TCM file, is also excluded since RMM does not define a working array for a constant supply analysis.

Naming of Program Files (Main Menu Option 2)

If option 2 is selected at any time from the Main Menu, the file name assigned to the LOG and TCM files can be changed. The first prompt listed after option 2 is selected asks if the current LOG file is to be saved. The LOG file must be saved if a record of the tasks already performed during the current session is desired. This is followed by the question asking the user to supply a new file name for the LOG and TCM files (8 characters, maximum length) before returning to the Main Menu.

Select Functional Form (Main Menu Option 7)

Once the Main Menu is displayed, the selection of the functional form is the only task required prior to the generation of the constant supply curve. Option 7 invoked from the Main Menu displays the two options available for definition of a constant supply curve:

Select Functional Form Menu

7) Constant quantity (vertical line)
8) Constant cost (horizontal line)
0) Return to Main Menu

Please enter functional form used
?

Select either option 7, vertical supply curve, or option 8, horizontal supply curve, to continue the analysis. RMM responds with a request for the range of the supply curve graph in terms of quantity, if a constant cost curve has been selected, or in terms of cost, if a constant quantity curve has been selected:

For the purpose of determining the range of the Supply curve graph and the
Equilibrium intersection, please enter the desired MINIMUM quantity
(trips) and the MAXIMUM quantity (trips).

Please enter minimum quantity
?
Please enter maximum quantity
?

The range of the plot will be "QQQQ" to "QQQQ"
Do you have any changes? [NO]

The example above illustrates the questions prompted to the user when the constant cost (horizontal) supply curve is selected. The minimum and maximum values input at the prompts are echoed back to the screen for confirmation of accuracy. The Main Menu is redisplayed when the ranges have been properly defined.

Display of Graphs
(Main Menu Option 8)

Option 8 from the Main Menu works as a toggle controlling the display of graphs in RMM. By default, a graph is displayed during a constant supply run for the horizontal or vertical supply curve only. Selection of option 8 suspends the display of the graph and changes the indicator on the line listing that option from [Yes] to [No]. No graph will be presented for the remainder of the analysis in that module or until option 8 is selected again and the switch is retoggled to [Yes].

Enter Your Own Coefficients, Then Run Economic Analysis
(Main Menu Option 11)

All the preparatory steps toward the development of the constant supply curve have been completed. Selection of option 11 from the Main Menu initiates the generation of the supply curve. RMM responds by displaying all the options available for entry and modification of coefficients:

```
                         Enter Coefficients Menu

1) Enter your own coefficients
2) Modify existing coefficients
3) Display and use existing coefficients
0) Return to Main Menu

Please enter number of choice from Coefficients Menu
?
```

If this is the first supply analysis on this particular RMM run, select option 1 at the prompt to enter the coefficient for the constant supply curve. RMM requests the value for the constant at the next prompt:

```
Please enter CONSTANT COST
?
```

CONSTANT COST is displayed if a horizontal supply curve was specified during the selection of the functional form. RMM prompts with CONSTANT QUANTITY when the functional form is a vertical supply curve. The value you input is listed for your review followed by the prompt:

```
Do you have any corrections?                                   [NO]
?
```

Enter a "Y" response to correct the value listed. An "N" response is followed by the listing of regression statistics and analysis of variance table. In this context, only the constant coefficient has meaning since the actual regression analysis was not performed. The other sections in the table have been labeled "N/A" to inform the user that those statistics are not applicable to the method of analysis selected. The graphing of residuals is also suspended.

In response to a prompt to continue, RMM immediately displays the supply summary table and the supply curve. Note that the summary table lists the same marginal cost value across all quantity levels for the generation of a constant-cost horizontal supply curve. A vertical supply curve is reflected by the same quantity assigned to various cost levels. The supply curve is generated between the minimum and maximum ranges input during the selection of the functional form.

Following display of the supply curve, RMM offers the option of running the analysis a second time with a new constant defining the supply curve. If this option is desired, answer "Y" to the following question:

```
You may change your coefficients and run the economic analysis again.
Do you want to do so?                                          [YES]
?
```

Otherwise, an ''N'' response returns you to the Main Menu. If you chose to rerun the analysis with a different coefficient, RMM returns you to the Enter Coefficients Menu. From that menu, select option 2 to modify the constant entered for the previous supply curve. Option 3 relists the constant from the previous analysis and runs the economic analysis a second time. Note that RMM uses the functional form and the minimum and maximum ranges from the previous analysis to define the supply curve with the new coefficient on the constant.

Exit RMM
(Main Menu Option 99)

Exit RMM from the constant supply curve option using the procedures described in the ''Exit RMM'' section of the ''RMM Demand Analysis.'' Since a data matrix is not defined and variables are not identified during a constant supply run, RMM does not provide an option for saving the working array on a TCM file.

EQUILIBRIUM ANALYSIS

The equilibrium module of RMM estimates partial equilibrium by calculating the point of intersection between the second stage demand function and the supply function. For this equilibrium estimate to be valid, both curves must describe exactly the same good and three key assumptions must be made: (1) Travelers perceive a travel cost dollar to be equal to a dollar paid at the gate for entry to the site. (2) Prices of all goods except the fee at the entry to the site are fixed, including prices at substitute sites. (3) All variables that influence supply and demand for the site are fixed except those specified in the supply and demand functions.

Given these assumptions, the second stage demand function tells the site operator how many trips per time period to expect at different fee levels. The supply function used in RMM describes the relationship between the site operator's marginal cost and the number of trips provided per time period. The point of intersection defines the price and quantity at which marginal willingness to pay at the site equals the operator's marginal cost. Operating the site at this price and quantity is economically efficient, meaning that it maximizes the net economic benefit produced by the site (all other things held constant). At equilibrium, RMM calculates the consumer and producer surplus, the equilibrium price, and the equilibrium quantity.

The second stage demand function estimated in RMM applies only to the site in question. A major recreation site tends to be unique and locationally monopolistic, so the demand function is generally downward sloping. Under perfect competition, the demand curve would be horizontal, meaning that there is an inexhaustible supply of equally priced substitute sites. If the operator were to raise price, all visitors would divert to other sites. In such a case, the equilibrium price also maximizes the operator's profit. In general, however, the market for a major recreation site is not perfectly competitive, and the profit-maximizing price is not economically efficient from a social perspective.

Equilibrium analysis in RMM requires the supply and demand functions be commensurate, meaning that they must describe the same good across the same time period. For example, if the unit of consumption in the demand function is person-trips per year, the supply function must relate the operator's marginal cost to the number of person-trips per year, not persons at one time, person-days per year, recreation visitor days (RVDs) per year, or units of capacity at the site. Furthermore, it is important to distinguish between the units RMM requires for estimation of the first stage demand equation (recall equation [2]) versus the units employed in the plot of the second stage demand curve (fee increase versus total trips). The dependent variable in the first stage demand equation is estimated on a per-capita basis (i.e., person-trips per-capita per year). During the economic analysis, RMM converts that dependent variable to total person-trips per year for the plot of the second stage demand curve. Since the equilibrium analysis describes the intersection between the supply function and the second stage demand curve, the units of the supply analysis must match the units RMM uses for the second stage demand curve.

In recognition of the complexity and limited information available concerning estimation of supply functions, the equilibrium module has been designed to provide useful results even though a formal supply analysis is not feasible. Recall that one of the options in the supply module is the generation of a constant supply curve, vertical or horizontal. These constant curves represent supply-side constraints on either capacity or price. When equilibrated with the demand analysis, these constraints can be shifted to illustrate the impacts of different policy decisions. The impacts can be measured by the magnitude and direction of the change in consumer surplus reported in the equilibrium module. The analysis of questions pertaining to demand-side issues is enhanced by applying the constant supply curves in the equilibrium analysis.

EXECUTE EQUILIBRIUM

The equilibrium analysis is performed only after completion of the demand and supply modules during one RMM session. Both modules must produce successful runs (i.e., the generation of summary tables and associated

economic analyses). RMM stores the results from the first module (demand or supply) during completion of the second module (supply or demand), then combines the results from both modules to perform the equilibrium analysis. Although it is not important which module (demand or supply) is completed first, it is easier to perform multiple equilibrium analyses during the same RMM session if supply is executed last. The range of analysis for equilibrium is controlled through the supply module. Select option 1 from the Main Menu to move from one module to the other without exiting RMM.

The equilibrium analysis is not listed as an option in any menu in the program. After both the demand and supply runs have been completed, RMM prompts the following message to the screen:

You have completed BOTH Demand and a Supply analyses.

Do you want to perform Equilibrium analysis. [YES]
?

Assume you have completed the supply module and are currently running the economic analysis in demand. Immediately following the table listing the revenues and revenue changes, RMM initiates the equilibrium module by displaying the message listed above. Conversely, if your second module (current module) is a supply analysis, the question pertaining to equilibrium is displayed immediately after the supply curve is echoed to the screen. In other words, the equilibrium module can only be accessed after completion of the economic analysis for the second of the two modules and before returning to the Main Menu for that module.

Initialize the equilibrium analysis with a "Y" response to the question above. Otherwise, you will either be returned to the Main Menu or, in some cases, given the option of changing your coefficients and running the current analysis a second time. Whether you chose to complete an equilibrium analysis or not, RMM always returns you to the current module (demand or supply), from which you can exit RMM or restructure your analysis.

EQUILIBRIUM RESULTS

RMM displays the results of the equilibrium analysis immediately after the question ascertaining whether or not the analysis is to be performed. RMM produces a summary table of the results obtained from both the demand and supply analyses. The table shows the predicted total trips at each simulated fee increase on the demand side and the estimated total trips provided at various marginal cost levels on the supply side.

The equilibrium analysis next displays a graph of the estimated curves represented by the data points displayed in the summary table provided by RMM, but only if the program is able to derive the intersection between the two curves. An algorithm is included in the program to solve for the equilibrium point. Recall that the supply curve graph is plotted between maximum and minimum values input by the user during the identification of the functional form (option 7 from the Main Menu) for the supply analysis. RMM uses this range as the end or extreme points in the search for the equilibrium solution. A cursory scan of the table listed above the graph should reveal the approximate magnitude of the equilibrium point between supply and demand. Equilibrium occurs when the cost (fee increase) and quantity values for demand equal the corresponding values for supply. Some interpolation between points will be necessary to narrow the solution. The equilibrium solution reported by RMM can be verified using the value estimated from the summary table.

If RMM fails to compute an equilibrium, the graph is not produced and RMM states:

Equilibrium point OUTSIDE range of graph
Producer surplus and consumer surplus will NOT be computed

Most often this occurs when the search for the equilibrium solution (range of the supply curve graph) has been defined too narrowly and the intersection between the curves falls above or below the specified range. Since RMM was not able to locate the equilibrium, the solution does not occur within the range of cost and quantity values listed on the supply side of the summary table described above. Yet, you should be able to determine whether the equilibrium point occurs above or below the range of costs specified for supply. From that information define a new set of maximum and minimum values which bracket your best estimate of the equilibrium point. If no approximation to the equilibrium solution can be identified, simply increase the range of values in both directions.

The maximum and minimum values defining the range of the search for the equilibrium solution can only be reset from the Select Functional Form Menu in the supply analysis. If the equilibrium analysis was entered from the supply module, return to the Main Menu and select option 7 to input the new set of maximum and minimum values. Rerun the supply analysis (either option 10 or 11 from the Main Menu) and the equilibrium analysis will automatically be initialized with the results retained from the demand analysis and the new range of values for the equilibrium search. If equilibrium was entered from the demand module, the supply analysis must be redone completely. Return to the Main Menu and select option 1 (Type of run) to initiate a new supply run. The results

from the demand analysis are automatically retained for the next equilibrium pass and remain available until a new demand run is performed or RMM is terminated.

When an equilibrium solution is obtained, RMM displays the graph of the two curves and reports the coordinates of the equilibrium point.

The EQUILIBRIUM point is "QQQQ.QQ" trips at "$$$$.$$"

Consumer Surplus: "$$$$.$$"
C. S./ Trip : "$$$$.$$"

The equilibrium quantity is the number of trips demanded by consumers and supplied by producers at the equilibrium price. The consumer surplus value and the consumer surplus per trip are automatically calculated by RMM and provide measures of the benefits to consumers faced with a fee increase (per trip) equal to the equilibrium price. Consumer surplus is shown in figure 6 as the area under the second stage demand curve between the equilibrium price and the intercept on the price (fee increase or marginal cost) axis.

The calculation of producer surplus is an option in RMM requiring input from the user concerning the range of marginal costs across which the surplus is to be determined. Producer surplus (fig. 6) is the area above the supply curve, below the equilibrium price level. It represents economic benefits to the supplier equal to the difference between the amount actually received and the minimum amount the supplier is willing to accept to produce the recreation opportunities (or the cost of producing the opportunities).

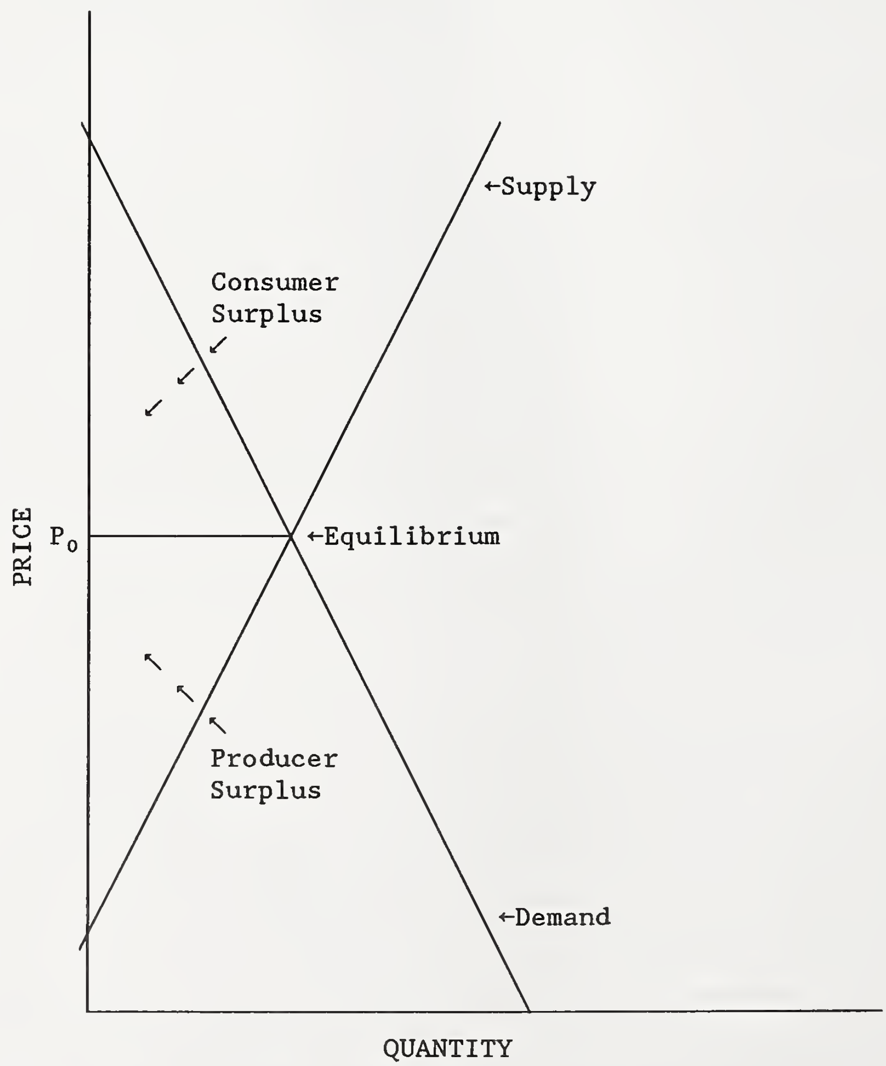

Figure 6.—Market equilibrium and consumer and producer surpluses.

The option to have the producer surplus calculated is presented after the consumer surplus values are displayed.

The producer surplus may also be calculated at this equilibrium point.
Do you want to do so? [YES]
?

To a "Y" response, RMM lists the intercept of the supply curve with the vertical axis (marginal cost) and recommends a lower bound on marginal cost for the computation of producer surplus.

The marginal cost intercept is "$$$$.$$", so "$$$$.$$" will be used as
the lower bound for computing producer surplus.
Is that OK? [YES]
?

RMM assigns $0.00 as the lower bound for producer surplus for all supply curves exhibiting a negative intercept with the marginal cost axis. RMM excludes from the producer surplus computations any area above the supply curve that does not reside in the first quadrant. In effect, this ignores the portions of the supply curve that extend below the horizontal axis or to the left of the vertical axis. For upward sloping supply curves, the user is given the option of specifying a higher value for the lower bound as long as it falls between the level proposed by RMM and the equilibrium value. RMM physically allows downward-sloping supply curves to be generated with the idea that the user is aware of the theoretical considerations inherent to such curves. The producer surplus is negative and is computed as the area under the supply curve between the limits imposed by the equilibrium value (lower bound) and the marginal cost intercept (upper bound). In this case, RMM allows the user to specify a value for the upper bound as long as the intercept is not exceeded and the equilibrium value remains the lower bound.

A "Y" response to the prompt listed above signals RMM to calculate the area above the supply curve between the lower bound (for upward-sloping supply curves), just approved by the user, and the equilibrium point. The range of marginal costs over which the producer surplus was calculated is displayed along with the value of the surplus, total, and per trip.

Producer surplus was calculated between marginal costs of "$$$$.$$"
and "$$$$.$$".

Producer Surplus : "$$$$.$$"
P. S./Trip : "$$$$.$$"

Under special circumstances a functional form may be estimated for the supply curve that does not have a finite intercept with the marginal cost axis. In most instances, these functional forms involve a log transformation of the dependent variable. RMM solves the supply equation for the marginal cost that generates exactly "1.0" trip and proposes this be one of the bounds, along with the equilibrium point, in the computation of producer surplus. The user is given the option of overriding this default level by providing a "new" level of trips from which RMM can solve for a surrogate marginal cost intercept. This special procedure is initiated if the user has specified a semi-log dependent or a double-log functional form for the supply curve. RMM prompts for approval to use the default value to calculate the intercept.

To estimate the marginal cost intercept for this functional form (which
involves the log of the dependent variable), estimated trips are set to
1.0 instead of 0.0

Is that OK? [YES]
?

Enter your own value after responding with an "N". Otherwise RMM solves for the marginal cost intercept at "1" trip and finishes the computation of producer surplus using the procedures described above for the functional forms not requiring special treatment. Even with the identification of a surrogate marginal cost intercept, the lower/upper bound on marginal cost must meet the limitations imposed by RMM to constrain the producer surplus calculation to only that area above the supply curve that lies in the first quadrant.

At this point, the equilibrium module is complete and RMM returns to the Main Menu of either the demand or supply module. Exit RMM by entering "99" at the prompt or initiate a new demand or supply run by selecting option 1 from the Main Menu. (Refer to the exit instructions in either the demand or supply sections of this manual for more details.)

EXAMPLES OF MODEL APPLICATION

RMM is useful for answering a number of policy and planning questions. Recreation policies on public lands can be analyzed by the comparison of changes in equilibrium price and quantity, consumer surplus, and producer surplus, as variables that affect supply and demand are changed in the model. The effects of policy actions can be evaluated before implementation of a decision. The following examples illustrate applications:

What is the value of this recreation site? Use RMM for travel cost analysis and estimate consumer surplus for the site. The total consumer surplus (if total use is known) estimates the users' net willingness to pay to avoid closure of the site. This number is the net demand-side economic benefit. The average consumer surplus estimates the average visitor's net willingness to pay to avoid closure. Use RMM to estimate a supply function (or input a known supply function) and estimate the operator's producer surplus. Producer surplus is the operator's real profit and is the supply-side net economic benefit. The economic benefit produced by the site is the sum of producer and consumer surplus.

What is the value of the marginal visit? Use RMM to calculate the equilibrium price and the average consumer surplus. If price controls consumption and price is set at marginal cost, the demand-side economic value of the marginal visit is the equilibrium price. The visitor pays that price to the operator. The operator in turn pays out that amount in marginal cost. Net benefit to the operator, to the consumer, and to society from the marginal unit is thus zero. If lottery rationing controls consumption, we have no way of knowing which visitor is excluded if we reduce visits by one (at the margin). The on-site expected value of the marginal visit on the demand side is thus the fee paid plus average consumer surplus. The expected net demand-side value is average consumer surplus. If the fee charged is the marginal cost of the marginal unit, net value to the producer is zero, and the expected net value to society is the average consumer surplus.

What is the economic value of (this type of) recreation opportunity in a region? For most kinds of recreation opportunity for which the market is not purely competitive, the notion of a regional price is nonsense. Because of unique site characteristics or locational advantages, the market for each recreation site is unique. The only way to answer this question using RMM is to calculate (as above) either site value or marginal value for a representative sample of sites in a region and then report the average or expected value for the region. It may be possible to estimate a regional first stage demand function that includes site characteristics and other variables that change from site to site. Such a model then can be used to estimate a second stage demand function for any site in the region, but locational differences alone will make that function unique for each site.

What is the effect of a change in the price of gasoline? The price of gasoline helps determine travel cost; therefore a change alters the second stage demand function. To analyze the effect of a change in the price of gasoline, calculate the vehicle cost per mile at the old and new prices. Run RMM at each vehicle cost and compare the results. The comparison will show changes in the second stage demand function, changes in consumer and producer surplus, and changes in quantity and marginal price at equilibrium.

What is the effect of a change in the entrance fee? The effect of a change in entrance fee is not the same as the effect of a change in the price of gasoline, even when the dollar amount is the same. A change in the price of gasoline causes a proportional change in travel cost across a market area, resulting in an absolute change in price for people living at different distances from the site. A change in entrance fee is the same for everyone in absolute amount, but constitutes a different proportional change in price as a person's distance from the site varies. Since the second stage demand function shows the relationship between fee increase and total visits, the impacts of a fee increase on use levels can be evaluated directly using RMM. Simply locate the fee increase in the table summarizing the second stage demand function or from the graph of the demand curve and read the expected level of visitation. To analyze the effect on surplus, use the equilibrium module, and shift the supply curve by the amount of the change in fee. If no supply curve was used in the analysis, run the demand analysis a second time and follow that with a supply run. Generate a horizontal (constant) supply curve at a marginal cost level equal to the fee increase. The equilibrium module will display the consumer surplus and the total visits estimated at the level of the fee increase.

What is the effect of a change in site characteristics? Changes in site characteristics can be analyzed with RMM if the characteristics in question have been specified in the demand and supply equations. Simply run RMM under conditions 1 and 2 and compare results. Remember that a change in site characteristics may shift both the supply and demand functions. The effect of congestion is a special case. Congestion effects can be included either as a quality variable that shifts the demand function or as a cost variable that shifts the supply function.

What is the effect of demographic changes? Although demographic changes generally occur slowly over time, significant changes in the characteristics of the client population may go beyond the ability of available demand and supply functions to predict into the future. That is, even though we may be able to predict demographic changes with reasonable accuracy, we cannot be confident that the structure of the demand and supply processes will remain constant while those changes are occurring. Nevertheless, RMM can be run with and without changes to the demographic variables. Comparison of results will show the effect of demographic changes under the assumption of stable supply and demand processes. Such analysis is not possible, however, unless the supply and demand functions include the demographic variables in question.

What are the effects of different rationing schemes? With rationing schemes that allocate opportunities randomly, average consumer surplus is the appropriate measure of marginal net benefit to the consumer. Entering the quantity constraint in RMM as a vertical supply function in equilibrium analysis yields estimates of total and average consumer surplus, as well as producer surplus. Price rationing policies that use prices other than the marginal cost price can also be evaluated with RMM. Simply define the supply function in terms of the pricing policy in question and perform equilibrium analysis. For example, one pricing policy might be marginal cost plus (minus) a constant. Another might simply be a fixed price, i.e. a horizontal supply function. In any case, remember that net benefit to society consists of consumer surplus plus producer surplus. In those cases where producer surplus is negative, such as with a downward-sloping supply curve, or where the government subsidizes recreation supply by charging less than marginal cost, the producer surplus reduces net benefit.

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APPENDIX A
ADVANCED ISSUES IN TRAVEL COST ANALYSIS

Users of RMM might want to use the program to do things it was not originally intended for. Also, technical issues do arise. What follows is an attempt to address some of these issues. Readers of this section are assumed to be fairly familiar with the TCM and statistical data analysis.

PERFECT SUBSTITUTES

The discussion of substitutes in the demand program section of the text proceeded under the assumption that substitutes to the study site were not perfect substitutes. Perfect substitute sites and their application to RMM are discussed in this section. After the estimation of the demand equation (options 10 or 11 from the demand Main Menu), the printing of the analysis of variance table and the plot of residuals, RMM reports the increase in trip cost (i.e., fee increase at the site) that is necessary to drive visitation from all the origins to the study site to zero.

A fee INCREASE of "$$$$.$$" results in ZERO trips from all origins
The last origin to produce trips is "Number of Origin"

Recall equations [3], [4], and [5] from the text. Let

$$VC_i = f(C_i, S_i, Z_i)$$

represent the demand equation the user has fit with multiple regression. Then, the predicted visitation at a given fee increase, ΔC_i, is

$$VC_i(\Delta C_i) = f(C_i + \Delta C_i, S_i, Z_i).$$

The fee increase needed to drive trips to zero for a given origin i is

$$0 = f(C_i + \Delta C_i^*, S_i, Z_i).$$

The fee increase reported in RMM is the maximum of the ΔC_i^* and represents the largest fee increase required to drive trips to zero from all origins.

Following the report of the maximum fee increase required to generate zero trips from all origins, RMM asks whether demand cutoff points should be used in the economic analysis. Demand cutoffs should be applied in TCM analyses when a perfect substitute has been identified for the study site. Recall, a perfect substitute site is one that offers the same recreation opportunities at an equal or higher quality, and has sufficient capacity to handle the increased use that would result if the study site were closed. A perfect substitute site sets an upper bound on the willingness of recreationists to pay for entry to the study site. The price of a trip from an origin to the closest perfect substitute site is termed the "demand cutoff" point for that origin. If fees at the site are raised to a level that the travel cost plus fees exceed the demand cutoff point for an origin, then trips from the origin to the study site are assumed to be zero. All recreationists from the origin would travel to the perfect substitute site. This is the logic that is implemented when the demand cutoff option of RMM is invoked. Since the price of a perfect substitute should not be used in the demand equation itself, RMM provides the demand cutoffs as a mechanism for addressing perfect substitutes.

From the last equation above, let

$$C_i^* = C_i + \Delta C_i^*.$$

C_i^* is the cost at which the demand equation predicts zero trips from origin i. Let the cost of a trip from origin i to the nearest perfect substitute site be represented as C_i'. The C_i' values must be entered by the users, as discussed later in this section.

When demand cutoff points are used, trips from origin i to the study site are modeled as zero whenever

$$C_i + \Delta C_i > \tilde{C}_i$$

where $\tilde{C}_i$ = minimum of C_i^* and C_i'.

Even when the demand equation predicts positive trips from an origin, trips from that origin are assumed to fall to zero if $(C_i + \Delta C_i)$ is greater than the demand cutoff (C_i'). Conversely, when the C_i' from each origin is greater

than C_i^*, the demand equation predicts zero trips at a cost (i.e., at C_i^*) lower than C_i'. C_i^* becomes the upper bound or maximum effective demand cutoff and C_i' has no impact on the economic analysis. RMM always uses the minimum of C_i^* or C_i'. The logic behind these cutoff points is discussed by Knetsch (1977).

If there is a perfect substitute site, a "Y" response should be given to the demand cutoff prompt provided by RMM.

Invoke demand cutoff points option [NO]
?

From the list below, select the method you plan to use to enter the cutoff points in RMM.

Cutoff Points Menu

1) Enter cutoff points (one by one)
2) Specify COLUMN of cutoff points
0) Don't use cutoff points after all

Please enter number of choice from Cutoff Points Menu
?

The simplest way to enter demand cutoff points is to create a variable in your working array that contains the cutoff values. This variable must have a cutoff value for each origin in the market area. After a "2" is entered in response to the prompt above, RMM asks for the name of the variable assigned to the column of demand cutoff points.

Please enter variable containing cutoff points
?

Option 1 from the Cutoff Points Menu displays, origin by origin, the value of the demand cutoff currently in effect and the cost that drives trips to zero from each origin, i.e., C_i^* (maximum effective). If this is your first time through the cutoff points menu, the two values are the same. Following each display, RMM prompts for the demand cutoff value (C_i') for each origin. If there is more than one perfect substitute, use the one with the minimum cost for each origin.

In case you inadvertently entered the Cutoff Points Menu, option 0 allows you to proceed with the economic analysis without invoking demand cutoff points (i.e., proceed with C_i^*).

Regardless of the method (option 1 or 2) chosen to enter the cutoff points, RMM displays:

List NEW cutoff points [YES]
?

Receive a listing of the cutoff points to be used in the economic analysis by responding positively to the prompt. Inspect the cutoff points to determine if the values you entered were correct. RMM sometimes replaces your cutoff points with a value that is lower than the cutoff point you entered because RMM uses the minimum of either C_i^* or C_i' in the economic analysis. If C_i' is entered and is larger than C_i^*, RMM uses the C_i^* value. The list echoed to the screen reflects these substitutions. The following message is displayed on the screen if all the demand cutoff values are greater than the C_i^* values.

Each entered cutoff point is GREATER THAN the price at which
the Demand equation predicts "0" trips from that origin.
Thus, the economic analysis is unaffected and RMM defaults
to the price at which "0" trips are predicted (i.e., no
cutoff points). Specify different cutoff points or proceed
without using cutoff points.

Otherwise, following the list of cutoff values, RMM prompts to proceed with the analysis:

OK to use your new Demand cutoff points? [YES]

If the demand cutoff points are satisfactory, select "Y" and proceed with the economic analysis. Under the influence of demand cutoff points, the second stage demand curve is likely to have the truncated shape shown in figure A-1.

Enter an "N" response to return to the Cutoff Points Menu to enter a different set of cutoff points (option 1 or 2) or to suspend the use of cutoff points altogether (option 0). Note that the options available from the Cutoff

Figure A-1.—Truncated second stage demand curve.

Points Menu are not designed for easy editing of incorrect entries. Both options 1 and 2 require all cutoff points be reentered even if only a few changes are required. Option 1 is useful at this stage since it lists both the demand cutoff points currently in effect and the maximum effective values (C_i^*).

The perfect substitute assumption is a strong one. If you are not certain whether a substitute site is an imperfect or a perfect substitute, RMM can be run both ways to achieve the best TCM model. To run RMM with a site as an imperfect substitute, the imperfect substitute price term should be included in the regression equation. With the questionable site entered as an imperfect substitute, the second stage demand curve can be generated without demand cutoff points. Run the analysis a second way by assuming the substitute site is a perfect substitute. In this case, the price of the perfect substitute site would not be entered in the regression equation. Instead, the perfect substitute price would be reflected as a column of demand cutoff points. The reason the perfect substitute price cannot be entered into the regression equation is that if a site is a perfect substitute, it is assumed to be the same commodity as the study site. Economic theory does not allow the price of the single commodity to be entered into a demand curve twice.

FINER FEE INCREMENTS

The economic analysis for the demand module usually generates tables of estimated trips associated with rather large fee increases. For the purpose of formulating policies related to pricing a recreation area, it might be useful to have better resolution over a narrower range of fee increase alternatives. This resolution can be obtained by imposing a set of artificial demand cutoff points on the economic analysis. Generate a new column (variable) of data using option 5 from the Main Menu (Modify/Add/Display data). Define that column as the existing cost of travel from an origin to the study site plus a constant. Since the magnitude of the constant identifies the upper bound on the range of the fee increase table, set the value of the constant at the higher end of the range for which better resolution is desired. Execute the regression and economic analysis (option 10 or 11 from the Main Menu) and initialize the demand cutoff option in RMM. Select option 2 from the Cutoff Points Menu to specify the new column of data as the column containing the cutoff points. If, for example, the constant added was 10, the fee

increase/total trips table is generated across a range of fee increases between $0 and $10. Predicted trips are estimated at a fee increase interval of $.10, providing the maximum of 100 increments is selected. Keep in mind that this application invalidates the reported values for consumer surplus. However, the fee increase/estimated trip schedule is accurate between $0 and $10.

CALCULATING DISTANCES

In a travel cost model with many origins and many recreation sites, calculation of the distances from each origin to each site can be quite tedious. The usual means of calculating distances is a road map. An alternative technique in the case of many origins and many sites is to use geometry to estimate distances. For any two points X and Y, the airline (arc) distance between them is (U.S. Department of Commerce 1978)

$$A = [\cos^{-1}((\sin x \sin y) + (\cos x \cos y \cos P))]k_1$$

where A = airline distance between X and Y
x = latitude of point X
y = latitude of point Y
P = degrees of longitude between X and Y
k_1 = distance, in miles, of one degree of arc (68.989 is a general case for latitudes between 30 and 50 degrees).

It is assumed that latitude and longitude are measured in degrees and tenths of degrees, not in degrees followed by hours, minutes, and seconds. Another way to measure distance with geometry is to determine the checkerboard, or right angle, distance between any two points. The checkerboard distance between any two points X and Y is defined as

$$CB = k_2L + k_3P$$

where CB = checkerboard distance between two points X and Y
L = degrees of latitude between points X and Y
P = degrees of longitude between X and Y
k_2 = miles in one degree of latitude (69 miles)
k_3 = miles in one degree of longitude (53 miles at 40 degrees north latitude).

By recording the latitude and longitude of the recreation sites and origins, the checkerboard and airline distances between any two points can be calculated easily. Once the airline and/or checkerboard distances are calculated, the problem is to convert them into driving distances. To do this calculate actual driving distances from a road map for a random sample of the distances that need conversion. A correction factor can be developed to predict driving distances. The predicted driving distance between two points X and Y is

$$D\hat{D} = k_4G$$

where $D\hat{D}$ = predicted driving distance between X and Y
$k_4 = \frac{k_5}{k_6}$
k_5 = average driving distance for sample of points
k_6 = average distance for sample of points based on geometry
G = distance between X and Y based on geometry.

Whether or not to use the airline distance, checkerboard distance, or geometrically based distances is a matter of choice. The best predictor of driving distances is the one to select.

A more formal way of relating driving distances to geometrically based distances is to use regression analysis. Rosenthal (1985) used regression analysis to estimate the following equation relating driving distances to airline (A) and checkerboard (CB) distances:

$$D\hat{D} = 6.86 + 1.075A + 0.4789(CB - A)$$

$$R^2 = 0.98.$$

The U.S. Department of Commerce discusses this problem in more detail and has a published set of road circuity factors (U.S. Department of Commerce 1978).

ORIGINS WITH NO VISITS

Frequently, some origins in the market area deliver no trips to the recreation sites during the sampling period. For example, if origins are defined as counties within a 100-mile radius of the recreation site, trips from some counties might not have been sampled. The analyst is faced with the question of what to do with counties from which no visitation was observed. The solution depends on the functional form being used.

If the linear, quadratic, or semi-log independent functional forms are used, then zeros should be retained in the travel cost model. Zero trips from an origin to the site is a valid observation, which should be entered as a case, just like any other origin. The regression analysis, distance-to-cost conversions, and any other modifications would proceed as normal.

If the semi-log dependent or double-log functional forms are used, retaining zeros is not feasible. Taking the natural logarithm of zero is an undefined mathematical operation. A simple way to solve the problem of zeros is to redefine the boundaries of origins in the market area to eliminate origins with zero visitation. If origin 10 in figure 1 had a zero, the logical alternative would be to combine it with origin 9, 6, or 11. If origin 10 is combined with origin 9, then an aggregate origin representing the 9, 10 combination would result. The number of cases in the data set falls from 12 to 11. The visitation from this new origin would be the trips from 9 plus the trips from 10. In the example data set (table 1), there would be 356 trips from the new aggregate origin (356 trips from origin 9 and zero trips from origin 10). The population of the new origin would be the sum of the two populations, or 43,000. To calculate distances, per-capita income, and other demographic statistics population-weighted averages are usually used. For example, the population-weighted per-capita income and distance to the study site for the new aggregate origin would be $7,651 and 65 miles, respectively. The travel cost model is then run using 11 cases, with positive visitation recorded from all origins.

MULTICOLLINEARITY

Multicollinearity refers to the condition of two or more predictor variables in the demand equation being highly correlated.

Consider the layout of origins and recreation sites shown in figure A-2. To run the TCM, four distances for each origin must be calculated—the distance from the origin to the study site and to each of the three substitute sites. When these data are used in the regression portion of RMM, multicollinearity between the sites causes problems. The two substitute sites in origin 5 are adjacent to each other. The distances to each of them from each origin are nearly identical. In such a case, it is not necessary to incorporate both sites in the model. One of the sites, or a location between the sites, can be chosen to represent the combination of those two sites. Combining substitute sites in this manner should be done only when they are very close to each other. Otherwise, it is best to enter the separate sites in the RMM model.

A much more severe problem occurs if the substitute site is very close to the study site. For example, assume a substitute site is located at point "A" in origin 7. To run the TCM, the distance from each origin to each site in the market area is needed. Because the study site and point A are so close together, the distance measured to these sites from each origin will be almost identical. When the regression is run, little confidence can be placed on the own-price regression coefficient for the study site.

There are three ways to deal with this problem. First, the study site can be redefined to represent the combination of the original study site plus site A. In such a case, the two sites are valued as a single site. Total trips are defined as trips to either the study site or site A. A central point between the two sites is selected for calculating distances. When the site is redefined in this manner, it is not possible to use the TCM to make statements about the value of either the original study site or site A in isolation.

Second, you can assume that site A represents a perfect substitute to the study site. A perfect substitute provides recreation opportunities of equal or higher quality and has enough excess capacity to maintain this quality in the face of increased use that occurs if the study site is closed. Recall that the price of perfect substitute is not incorporated as an independent variable in the regression equation. Instead, the prices of trips to site A are used as demand cutoff points to truncate the demand curve for the study site. This truncation reduces the economic benefits generated at the study site. This makes sense, because the loss in recreation opportunities of removing the study site is minimized by the availability of excess capacity and of quality opportunities at the perfect substitute located nearby.

The final way to deal with the multicollinearity problem is simply not to use the TCM. The TCM is not well suited to estimating the value of the study site alone in the face of such high multicollinearity. A study using the contingent valuation method may be better suited to determining the value of the study site.

COMPARING R^2 ACROSS FUNCTIONAL FORMS

Many statistical texts discuss the issue of how to select the "best" regression. Important factors to consider are theoretical reasonableness of the model, how well the model fits the data, residual plots, and the statistical

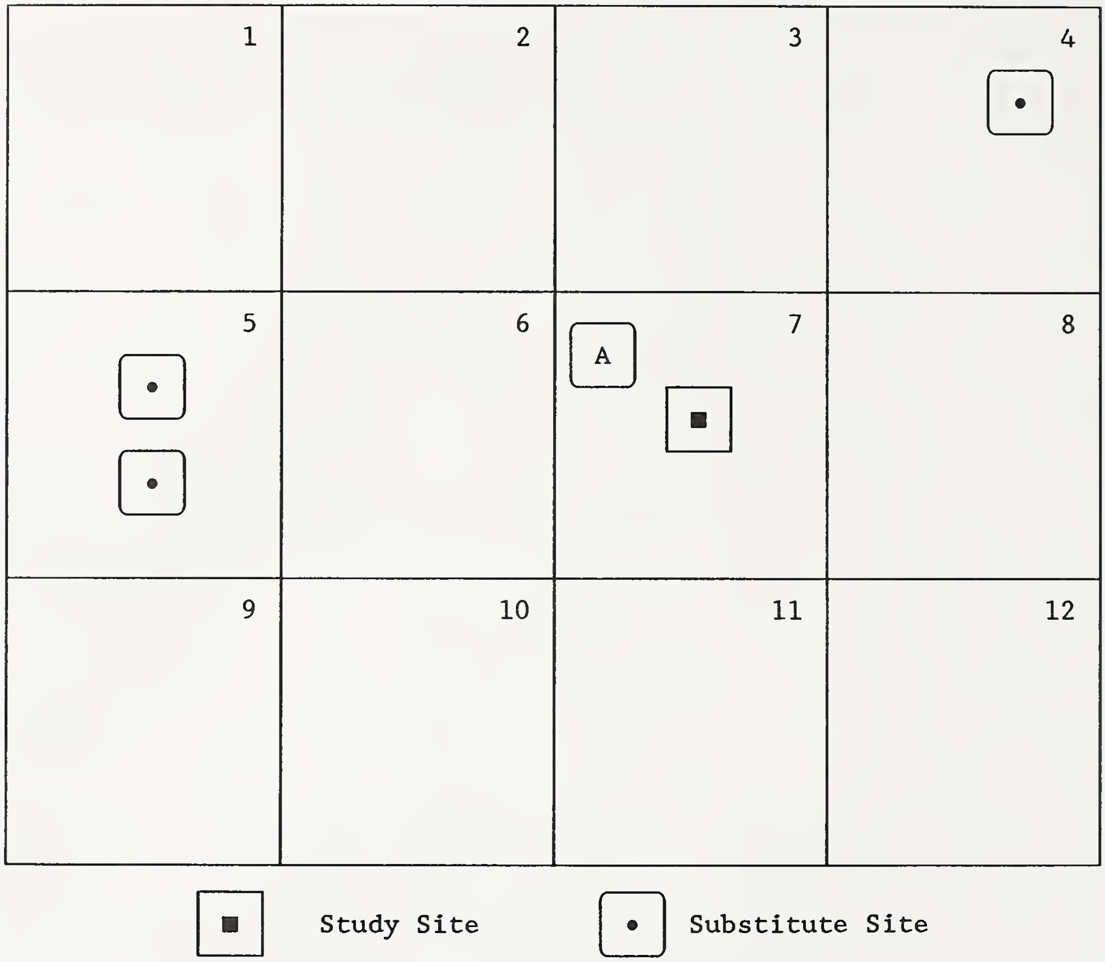

Figure A-2.—Multicollinearity.

significance of individual regression coefficients. The reader is referred to any good statistics text for a discussion of these issues.

With RMM, the user has the option of fitting functional forms where the logarithm of trips per capita is used as the dependent variable. The R^2 from these regressions cannot be meaningfully compared to the R^2 of regressions using trips per capita as the dependent variable because the dependent variables are measured in different units.

To compare a log-dependent variable regression with a regular regression, the dependent variables must be transformed into equivalent units. Following Rao and Miller (1965), redefine the dependent variable as

$$VC_i^* = VC_i/g$$

where $g = \exp[(1/n \sum_{i=1}^{n} (LN\ VC_i)]$

is the geometric mean of trips per capita. After this standardization, fit, for example,

$$VC_i^* = \beta_0 + \beta_1 C_1 + \epsilon_i$$

and

$$LN(VC_i^*) = \alpha_0 + \alpha_1 LN(C_i) + \epsilon_i'.$$

The equation with the lower residual sum of squares is the better fit. Standardization by dividing by the geometric mean of the dependent variable allows direct comparison of residual sums of squares.

INDIVIDUAL-OBSERVATION TRAVEL COST MODELS

The RMM program can be adjusted to run individual-observation TCMs (Brown and Nawas 1973). In the zonal TCM, visits per capita from each origin is regressed on price, income, and other predictors. In the individual TCM, the number of times each person visits the site is regressed on price, income, and other variables. The difference between the two approaches results from aggregation.

The individual-observation-based TCM can be run on RMM by treating each individual as a zone with a population of one. This approach to an individual-observation TCM model has the same number of origins as there are individual observations. A column of 1's is used to represent the population of these pseudo-origins. Once this is accomplished, the analysis proceeds in exactly the same manner as the zonal TCM.

Brown et al. (1983) point out a serious shortcoming in the individual-observation-based TCM. Because only participants are included in the data set, the individual-based model does not reflect a person who stops visiting the site when faced with a price increase. To correct this deficiency, they suggest using a new dependent variable termed ''individual observed visits per capita.''

The details of their approach cannot be described here except to say that such a model can be run easily on RMM. This model is clearly superior to the simple individual-observation-based TCM. To use this approach, first calculate individual-observed visits per capita as

$$\mathrm{vcap}^{*}_{ir} = t_{ir}\,(R_i/P_i)S$$

where vcap^{*}_{ir} = individual-observed visits per capita for the rth sampled recreationist (r = 1, R_i) from the ith (i = 1, n) origin
t_{ir} = number of trips to the study site made by the rth person from the ith zone
R_i = number of recreationists sampled from the ith zone
P_i = population of the ith zone
S = expansion factor to correct for the sampling rate, i.e., 1/(proportion of visitors sampled).

Then use vcap^{*}_{ir} as the dependent variable in RMM; LN(vcap^{*}_{ir}) also can be used as a dependent variable when fitting logarithmic functional forms.

Every value of vcap^{*}_{ir} is treated as a zone in RMM. The calculation of benefits in RMM requires a population value for each of the zones. When you use RMM to run the Brown et al. (1983) model, the population associated with a given value of vcap^{*}_{ir} is (P_i/R_i). Every observation from the ith origin has the same population, (P_i/R_i).

Do not be confused between the origin zones formed by the user and the number of analysis zones RMM thinks there are. In the user's mind there are n zones (i = 1, n). When emulating the Brown et al. (1983) model in RMM, the program thinks there are ($R_1 + R_2 + \ldots R_n$) zones (i.e., as many zones as there are people). Each of these people-zones has an associated population, (P_i/R_i).

Once the value of vcap^{*}_{ir} and the associated population has been entered the analysis proceeds as normal. Users can try the sample data given in table 1 of Brown et al. (1983) as a check to see if they have set up the problem correctly.

The Brown et al. model assumes that the data on individual visit rates to a specific site were collected by either a household survey or by a survey of license holders for a particular activity (e.g., fishing). Persons with zero values for t_{ir} are not included in the analysis. All persons visiting the site one or more times have an equal probability of selection. In contrast, if persons are interviewed as they enter or exit the site, this equal probability property does not hold. Persons who visit the site often are more likely to be sampled than are infrequent visitors. The reasonableness of using the Brown et al. (1983) approach with data collected at the recreation site is an open question. Estimating regression models when there is sample stratification on the dependent variable is discussed by Hausman and Wise (1981).

APPENDIX B
EXAMPLE RMM SESSION

Two listings from example runs of RMM are included on the program diskette in the packed file TESTRUN.EXE. Refer to the README.TXT file for instructions on how to unpack the test run files.

The first example run, TESTRUN1.TXT, lists the responses and output from an RMM session where the demand data from table 1 are input as an ASCII data file for a travel cost analysis. A horizontal supply curve is also generated in that session to illustrate the equilibrium analysis.

The TESTRUN2.TXT file illustrates the application of the TCM file and regression coefficients generated from the first run to replicate the results of that run using different options in RMM.

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